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Bantam

Trapezoidal Torque Amplifier Module

RoHS CE

Analog Inputs
- ±10 Vdc current reference
- Peak, continuous current & peak-time set

Analog Outputs
- Current monitor
- Current reference

Digital Inputs
- Amp Enable
- Fwd/Rev Enable (limit switches)
- Hi/Lo load inductance

Digital Outputs
- Amp OK
- Regen control
- Brake control

Feedback
- Digital Halls from brushless motors

Dimensions
- 53.3 x 45.7 x 15.2 mm
- 2.1 x 1.8 x 0.6 in

Actual Size

Model	Vdc	Ic	Ip
BTM-055-20	12~55	10	20
BTM-090-10	12~90	5	10

DESCRIPTION

Bantam is a compact, DC powered analog current amplifier for torque control of DC brush or brushless motors. It operates as a stand-alone driver taking a ±10V input from an external controller. Mounting to a PC board with solderless connectors facilitates low-cost, multi-axis designs.

The Amp Enable input interfaces to active LO signals up to 24 Vdc. Another digital input switches the current-loop gain from a high to low for load inductance compensation. Forward and Reverse Enable inputs are provided for limit switches.

A digital output for Amp-OK indicates the amplifier's status. There are two other digital outputs one of which can activate an external regenerative energy dissipator circuit and another for motor brake control.

Digital Hall feedback enables trapezoidal drive of DC brushless motors. For driving DC brush motors, these inputs are left unconnected and the motor connected between the U & V outputs.

Protections include I2T current limiting for peak and continuous current as well as peak time. Short circuits between outputs or to ground and amplifier over-temperature produce latching faults.

DEVELOPMENT KIT

A Development Kit is available that provides mounting and easy connectivity for the Bantam.

GENERAL SPECIFICATIONS

Test conditions: Load = Wye connected load: 2 mH + 2 Ω line-line. Ambient temperature = 25°C, +HV = HV_{max}

MODEL	BTM-055-20	BTM-090-10	
OUTPUT POWER			
Peak Current	20	10	Adc, ±5%
Peak time	1	1	Sec
Continuous current	10	5	Adc, ±5%
Peak Output Power	1045	855	W
Continuous Output Power	523	427	W
Output resistance	0.075	0.075	Rout (Ω)
Maximum Output Voltage	Vout = HV*0.97 - Rout*Iout		
INPUT POWER			
HV_{min} to HV_{max}	+12 to +55	+12 to +90	Vdc, Transformer-isolated
Ipeak	20	10	Adc (1 sec) peak
Icont	10	5	Adc continuous (Note 1)
PWM OUTPUTS			
Type	3-phase MOSFET, 33 kHz		
Commutation	Trapezoidal using digital Hall feedback		
CONTROL			
Analog Reference Input	±10 Vdc, 100 kΩ differential input impedance		
Bandwidths	Current loop: 2.5 kHz typical, bandwidth will vary with tuning & load inductance		
Minimum load inductance	200 µH line-line		
FEEDBACK			
Digital Halls	3, non-isolated, for brushless motor commutation		
	10 kΩ to +5 Vdc pull-up with 33 µs RC filter to 74HC14 Schmitt trigger		
Power	+5 Vdc @ 250 mA max. (J1-21, 22) to power Hall sensors or commutating encoder		
DIGITAL INPUTS			
Number	4		
[IN1] /Enable	Amplifier enable, LO active, HI disables		
/PosEnab, /NegEnab	Forward and reverse direction limit switch/enable inputs: HI will disable output current in direction		
Type	74HC14 Schmitt trigger operating from +5 Vdc with RC filter on input		
	Vin-LO < 1.35 Vdc, Vin-HI >3.65 Vdc, input voltage range 0 to +24 Vdc		
	10 kΩ to +5 Vdc pull-up, 74HC14 Schmitt trigger operating from +5 Vdc with RC filter on input		
	74HCT, Vil = 0.8 Vdc max, Vih = 2.0 Vdc min, input voltage range 0 to +24 Vdc		
[LoInd] Low Inductance	HI or open: for higher inductance loads, LO or grounded: for lower inductance loads		
ANALOG INPUTS			
Number	5		
Ref(+), Ref(-)	Command input for output current demand, ±10 Vdc		
Peak Current Limit	0.5 to 4.80 Vdc sets peak current limit from 10~100% of rated peak current		
Continuous Current Limit	0.5 to 4.87 Vdc sets continuous current limit from 10~100% of rated continuous current		
I2T Limit	0.5 to 5.00 Vdc sets 10~100% of I2T time		
Balance	±2.5 Vdc from the 2.5 Vdc quiescent state will adjust output current ±1% of peak rated current		
DIGITAL OUTPUTS			
Number: type	3: N-channel MOSFET, open-drain, 30 Vdc max, 100 mA max for [AOK] and [OUT1], 1000 mA for [OUT2]		
[AOK]	Amp OK: active LO when amplifier has no faults and will operate when enabled		
[OUT1]	Configured as external regen switch controller: will be LO to turn on regen switch		
[OUT2]	Brake control (external flyback diode required): will be LO when AOK and is enabled to release brake		
ANALOG OUTPUT			
Current Monitor	±3.0 Vdc @ ±Ipeak		
Current Ref	Monitor for current-loop command: ±3.0 Vdc = ±100% of rated peak current		

NOTES

1) Heatsink is required for continuous current rating.

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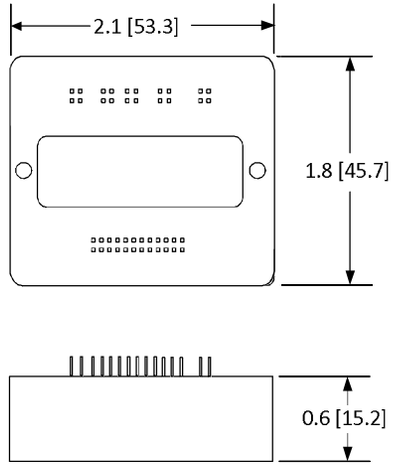
MOTOR CONNECTIONS	
Phase U, V, W	PWM outputs to 3-phase ungrounded Wye or delta wound brushless motors, or DC brush motors (U-V)
Hall U, V, W	Digital Hall signals, single-ended
Hall power	+5 Vdc ±2% @ 250 mAdc max
PROTECTIONS	
HV Overvoltage	+HV > HV_{max}, Amplifier outputs turn off until +HV < HV_{max} (See Input Power for HV)
HV Undervoltage	BTM-090-10: +HV < +12 Vdc, Amplifier outputs turn off until +HV > +12 Vdc
	BTM-055-20: +HV < +12 Vdc, Amplifier outputs turn off until +HV > +12 Vdc
Amplifier over temperature	Heat plate > 70°C
Short circuits	Output to output, output to ground, internal PWM bridge faults
I^2T Current limiting	Programmable: continuous current, peak current, peak time
MECHANICAL & ENVIRONMENTAL	
Size	2.1 x 1.8 x 0.6 [53.3 x 45.7 x 15.2] in [mm]
Weight	
Ambient temperature	0 to +45 °C operating, -40 to +85 °C storage
Humidity	0 to 95%, non-condensing
Contaminants	Pollution degree 2
Environment	IEC68-2: 1990
Cooling	Conduction through heatplate on amplifier chassis, or convection

AMPLIFIER DIMENSIONS



Dimensions in inches [mm]

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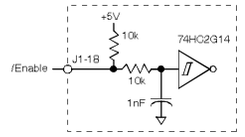
CONTROL INPUTS AND OUTPUTS

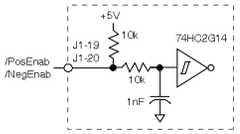
ENABLE INPUT

The Enable input [IN1] is LO-active and pulled up to +5V by an internal 10k resistor. This provides fail-safe operation by disabling the amplifier if the Enable input is open, or a wire from the controller should break.



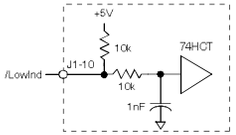
FWD/REV ENABLE INPUTS

Two inputs are provided for limit switches.
These should be LO for normal operation, and open or HI to inhibit current of positive or negative polarity.



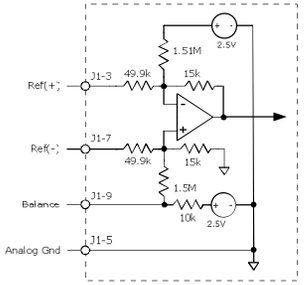
LOAD INDUCTANCE INPUT

The /LowInd input controls the gain of the current error amplifier to compensate the amplifier for lower or higher inductance loads. With the input open, the bandwidth will be ~2.5 kHz for a 2 mH (line-line) load. Grounding the input reduces the gain to 1/10 of the input-open gain for the same bandwidth with 200 µH loads.



ANALOG REFERENCE INPUT

The amplitude and polarity of the amplifier output current is controlled by a ±10V analog signal from an external controller.



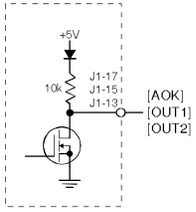
BALANCE INPUT

The output current of the amplifier can be adjusted to 0 Adc by connecting the balance input to a potentiometer with an adjustment range of 0 to +5 Vdc. This will produce an offset adjustment range of ±0.8% of the Ipeak rating of the amplifier. The table below shows the offset adjustment range in mA.

Model	±Ioffset (mA)
BTM-055-20	160
BTM-090-10	80

DIGITAL OUTPUTS

Three N-channel MOSFETs sink current from loads connecting to +30 Vdc maximum. Outputs [AOK] and [OUT1] can sink 100 mA maximum. The brake output [OUT2] can sink 1000 mA. An external flyback diode is required with driving inductive loads like a brake, or relays.

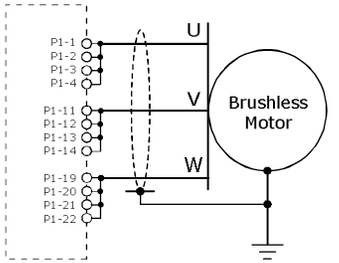


MOTOR CONNECTIONS

Motor connections are of two types for brushless motors: phases and Halls. For brush motors, only the armature connections are needed. The phase or armature connections carry the amplifier output currents that drive the motor to produce motion. The Hall signals are three digital signals used for commutating a brushless motor. When using a brush motor the Hall inputs should be unconnected and the motor armature connections made between the U & V phase outputs.

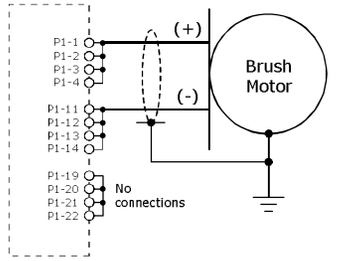
MOTOR PHASE CONNECTIONS: BRUSHLESS

The amplifier output is a three-phase PWM inverter that converts the DC buss voltage (+HV) into DC voltage waveforms that drive two motor phase-coils at a time (trapezoidal commutation). Cable should be sized for the continuous current rating of the amplifier. Motor cabling should use twisted, shielded conductors for CE compliance, and to minimize PWM noise coupling into other circuits. The motor cable shield should connect to motor frame and the equipment frame ground for best results.



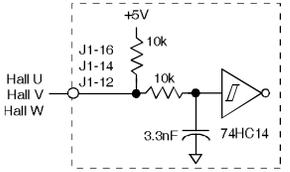
MOTOR PHASE CONNECTIONS: BRUSH

The amplifier output is an H-bridge PWM inverter that converts the DC bus voltage (+HV) into a DC voltage waveform that drives the motor armature. Cable should be sized for the continuous current rating of the amplifier. Motor cabling should use twisted, shielded conductors for CE compliance, and to minimize PWM noise coupling into other circuits. The motor cable shield should connect to motor frame and the equipment frame ground for best results.



MOTOR HALL SIGNALS

Hall signals are single-ended signals that provide absolute feedback within one electrical cycle of the motor. There are three of them (U, V, & W) and they may be sourced by magnetic sensors in the motor, or by encoders that have Hall tracks as part of the encoder disc. They typically operate at much lower frequencies than the motor encoder signals, and are used for commutation. When driving DC brush motors, the Hall inputs should be left unconnected.



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CURRENT LIMIT INPUTS

Two inputs are provided for setting the peak and continuous current limits. The I-Peak and I-Cont inputs each have equivalent circuits shown below. Limits can be set either by applying a voltage (Vset) to the input or by connecting a resistor (Rset) between input and signal ground. The tables below show values for Rset and Vset that give 10~100% of the rated peak and continuous current ratings.

AMPLIFIER MODELS AND RATINGS

Model	I-Peak	I-Cont	T-Peak	I2T
BTM-055-20	20	10	1	300
BTM-090-10	10	5		75

Note: I2T = (I_{peak}^2 - I_{cont}^2) * T-peak

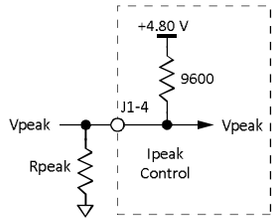
PEAK CURRENT LIMIT SETTINGS

%	Vpeak	Rpeak
100	4.80	<OUT>
90	4.32	86400
80	3.84	38400
70	3.36	22400
60	2.88	14400
50	2.4	9600
40	1.92	6400
30	1.44	4114
20	0.96	2400
10	0.48	1067

To use the table, find the % value as follows:

$$\% = \frac{\text{NewPeakCurrent} * 100}{\text{AmpPeak Current}}$$

EQUIVALENT CIRCUIT



EXAMPLE I-Peak SETTING

If a voltage Vpeak is used to control the peak-limit current, it can be found like this:

$$\text{Vpeak} = \frac{4.80 * \text{NewPeakCurrent}}{\text{AmpPeakCurrent}}$$

Example: find Vpeak for a 6 A NewPeakCurrent using a BTM-090-10:

$$\text{Vpeak} = \frac{4.80 * 6}{10} = 2.88 \text{ V}$$

To use a resistor for setting Peak-Limit current, calculate the value as follows:

$$\text{Rpeak} = \frac{9600 * \text{NewPeakCurrent}}{(\text{AmpPeakCurrent} - \text{NewPeakCurrent})}$$

Example: find Rpeak for a 6 A PeakLimitCurrent:

$$\text{Rpeak} = \frac{9600 * 6}{(10 - 6)} = 14{,}400 \text{ ohms}$$

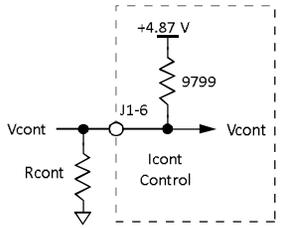
CONTINUOUS CURRENT LIMIT SETTINGS

%	Vcont	Rcont
100	4.87	<OUT>
90	4.38	88189
80	3.90	39195
70	3.41	22864
60	2.92	14698
50	2.44	9799
40	1.95	6533
30	1.46	4199
20	0.97	2450
10	0.49	1089

To use the table, find the % value as follows:

$$\% = \frac{\text{NewContCurrent} * 100}{\text{AmpContCurrent}}$$

EQUIVALENT CIRCUIT



EXAMPLE Icont SETTING

If a voltage Vcont is used to control the peak-limit current, it can be found like this:

$$\text{Vcont} = \frac{4.87 * \text{NewContCurrent}}{\text{AmpContCurrent}}$$

Example: find Vcont for a 3 A NewContCurrent using a BTM-090-10:

$$\text{Vcont} = \frac{4.87 * 3}{5} = 2.92 \text{ V}$$

To use a resistor for setting Cont-Limit current, calculate the value as follows:

$$\text{Rcont} = \frac{9799 * \text{NewContCurrent}}{(\text{AmpContCurrent} - \text{NewContCurrent})}$$

Example: find Rcont for a 2 A NewContCurrent:

$$\text{Rcont} = \frac{9799 * 2}{(5 - 2)} = 6{,}533 \text{ ohms}$$

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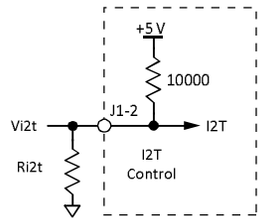
PWM LIMITING INPUT

I2T LIMIT SETTINGS

%	Vi2t	Ri2t
100	5.0	<OUT>
90	4.50	90000
80	4.00	40000
70	3.50	23333
60	3.00	15000
50	2.50	10000
40	2.00	6667
30	1.50	4286
20	1.00	2500
10	0.50	1111

EQUIVALENT CIRCUIT



I2T LIMITS (AMP²·SECS) OF AMPLIFIERS

I2T Limit = (Ipeak^2 - Icont^2) * 1 sec

Model	I2T Limit
BTM-055-20	300
BTM-090-10	75

EXAMPLES OF I2T SETTINGS

I2T Limit settings should be made after the peak and continuous current limits have been set. The time that the peak current can be maintained is then calculated based on the amplifier model and the new peak/continuous current limit settings. If a shorter peak time is desired, a new I2T Limit can be produced with an external voltage or resistor as described below.

Example 1: Find a the I2T limit for a BTM-055-20 with peak/continuous currents set to 12 & 9 A and a new peak time of 0.5 s
1) I2T Limit for BTM-055-20 = Amp I2T $A^2 \cdot s = (20^2 - 10^2)A^2 * 1 \text{ sec} = 300\ A^2 \cdot s$
2) Find new I2T A^2 for 12/9 limits = $(12^2 - 9^2)A^2 = 63\ A^2$
3) Find new peak time = Amp I2T $A^2 \cdot s$ / New I2T A^2, or 300 / 63 = 4.76 s

Example 2: Select an external resistor to shorten the peak I2T time for the peak/continuous current limits in Example 1 using the pre-set peak/cont current limits and a new desired peak time of 0.5 secs.
1) Calculate the new I2T Limit in $A^2 \cdot s = (12^2 - 6^2) * 0.5 \text{ sec} = 54\ A^2 \cdot s$
2) Find the ratio of the new I2T Limit to the amplifier I2T limit: (54 / 300) = 0.18, or 18%
3) Using the table above, find the nearest entry to 18% and install an external Ri2t with the table value 18% is close to 20%, and the table gives a value of 2500 ohms (2.5k) for this.
4) Or, calculate a resistor value that gives the exact new peak time desired:
Ri2t = 10000 * X / (1-X) where X = ratio of the new I2T Limit to the amplifier I2T limit (54 / 300)
Ri2t = 10000 * 0.18 / (1-0.18) = 2195 ohm. A 2.2k, 1% resistor is close to this value.
5) To find a voltage that can be applied to J1-2 to produce the same effect, multiply 5.0V X the ratio of I2T limits (54 / 300)
5.0 X (54 / 300) = 0.90 Vdc.

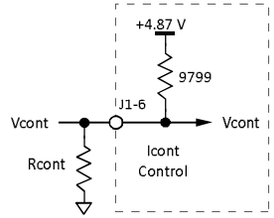
ABOUT PWM LIMITING

PWM limiting sets a maximum value for the on vs. off time of the outputs of the amplifier. While the peak voltage seen by the load remains about the same as the supply voltage (HV), the average voltage seen by the motor can be limited.
A common use of this is to limit the maximum RPM of a motor even though it's operating in torque mode.

PWM LIMIT SETTINGS

%	Rset (K)	Vset
97	<OUT>	4.95
78	42	4.00
70	30	3.71
68	25	3.54
62	20	3.3
57	15	2.97
45	10	2.48
38	7.5	2.12
28	5	1.65
25	2.5	0.99
25	0	0

EQUIVALENT CIRCUIT



EXAMPLE PWM SETTING

The table shows duty cycles measured with some choices of Rset for the PWM limits.

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PC BOARD DESIGN

Printed circuit board layouts for Bantam amplifiers should follow some simple rules:

1. Install a low-ESR electrolytic capacitor not more than 12 inches from the drive. PWM amplifiers produce ripple currents in their DC supply conductors. Bantam amplifiers do not use internal electrolytic capacitors as these can be easily supplied by the printed circuit board. In order to provide a good, low-impedance path for these currents a low-ESR capacitor should be mounted as close to the drive as possible. 330 µF is a minimum value, with a voltage rating appropriate to the drive model and power supply.

2. Connect P1 signals (U,V,W outputs, +HV, and +HV Common) in pin-groups for current-sharing. The signals on P1 are all high-current types (with the exception of the +24 Vdc Aux HV supply). To carry these high currents (up to 20 Adc peak) the pins of P1 must be used in multiples to divide the current and keep the current carrying capacity of the connectors within specification. The diagram on page 9 shows the pin groups that must be inter-connected to act as a single connection point for pc board traces.

3. Follow IPC-2221 rules for conductor thickness and minimum trace width of P1 signals. The width and plating should depend on the model of drive used, the maximum voltage, and maximum current expected to be used for that model. Power supply traces (+HV, +HV Common) should be routed close to each other to minimize the area of the loop enclosed by the drive DC power. Noise emission or effects on nearby circuitry are proportional to the area of this loop, so minimizing it is good layout practice.

Motor signals (U,V,W) should also be routed close together. All the motor currents sum to zero, and while the instantaneous value in a given phase will change, the sum of currents will be zero. So, keeping these traces as closely placed as possible will again minimize noise radiation due to motor phase currents.

Bantam circuit grounds are electrically common, and connect internally. However, the P1 signals carry high currents while the grounds on J1 (signal ground) carry low currents. So, J1 signals should be routed away from, and never parallel to the signals on P1. Encoder signal pairs (A, /A, B, /B, and X, /X) should be routed close together for good transmission-line effect to reduce reflections and noise.

The amplifier heatplate is electrically isolated from all drive circuits. For best noise-immunity it is recommended to connect the standoffs to frame ground and to use metal mounting screws to maintain continuity between heatplate and standoffs.

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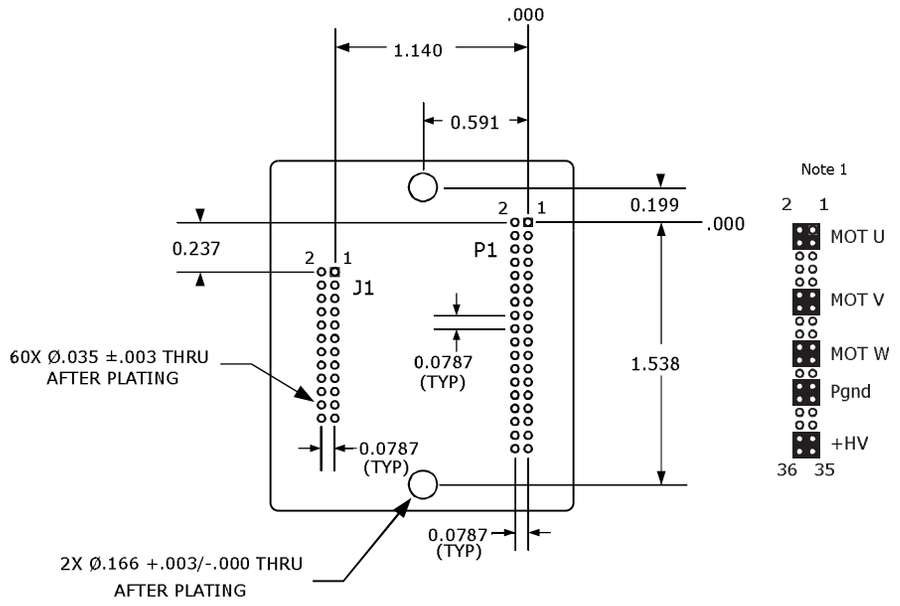
PC BOARD MOUNTING FOOTPRINT

Top View

Dimensions in inches



Accelnet Mounting Hardware:

Qty	Description	Mfgr	Part Number	Remarks
1	Socket Strip	Samtec	SQW-112-01-L-D	J1
1	Socket Strip	Samtec	SQW-118-01-L-D	P1

Notes

1. P1 signals must be connected for current-sharing.
2. To determine copper width and thickness for P1 signals refer to specification IPC-2221. (Association Connecting Electronic Industries, http://www.ipc.org)
3. Standoffs should be connected to etches on pc board that connect to frame ground for maximum noise suppression and immunity.

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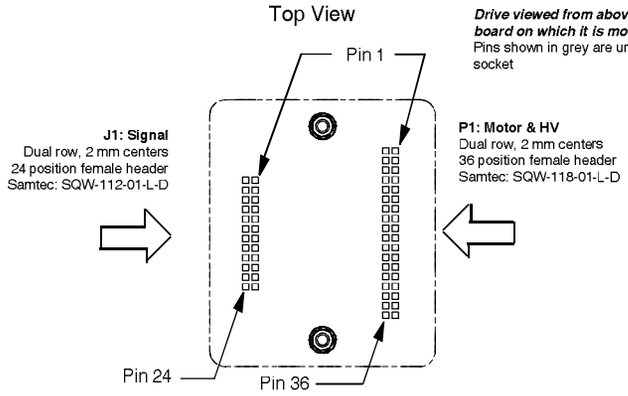
AMPLIFIER PC BOARD CONNECTORS



Drive viewed from above looking down on the pc board on which it is mounted.
Pins shown in grey are unused locations in PC board socket

J1 SIGNALS & PINS

Signal	Pin		Signal
I2T Time	2	1	Current Ref
Peak Curr Limit	4	3	Ref(+)
Cont Curr Limit	6	5	Agnd
PWM Limit	8	7	Ref(-)
/LowInd	10	9	Balance
Hall W	12	11	Current Monitor
Hall V	14	13	[OUT2]
Hall U	16	15	[OUT1]
/Enable	18	17	[AOK]
/NegEnab	20	19	/PosEnab
Hall +5V	22	21	Hall +5V
Pgnd	24	23	Pgnd

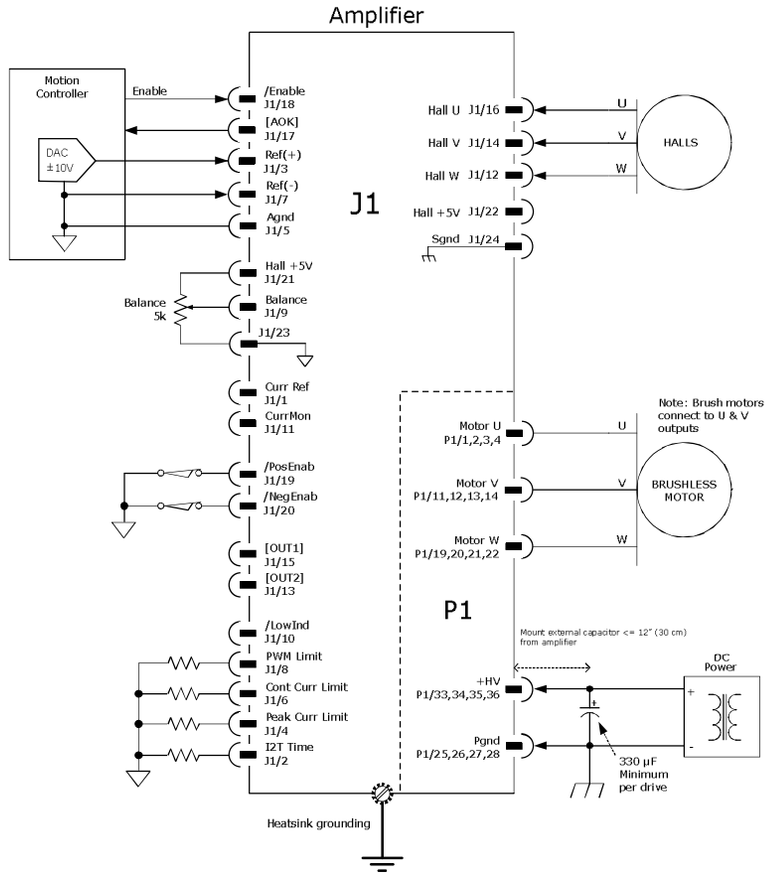
P1 SIGNALS & PINS

Signal	Pin		Signal
Motor U	2	1	Motor U
Motor U	4	3	Motor U
N/C	6	5	N/C
N/C	8	7	N/C
N/C	10	9	N/C
Motor V	12	11	Motor V
Motor V	14	13	Motor V
N/C	16	15	N/C
N/C	18	17	N/C
Motor W	20	19	Motor W
Motor W	22	21	Motor W
N/C	24	23	N/C
Pgnd	26	25	Pgnd
Pgnd	28	27	Pgnd
N/C	30	29	N/C
N/C	32	31	N/C
+HV	34	33	+HV
+HV	36	35	+HV

NOTES

1. Grey-shaded signal are N.C. (No Connection)
2. Signals are grouped for current-sharing on the power connector. When laying out pc board art-works, all pins in groups having the same signal name must be connected.
3. Total output current from +5V pins (J1-21,22) cannot exceed 250 mA.

AMPLIFIER CONNECTIONS



NOTES

1. Total output current from +5V pins (J1-21,22) cannot exceed 250 mA.
2. When Balance potentiometer is used, it should connect to amplifier +5V and ground for best stability.

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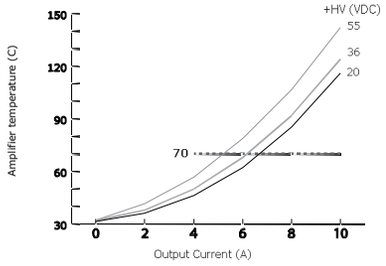
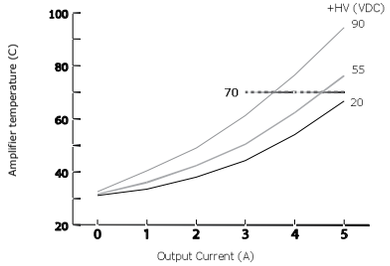
AMPLIFIER TEMPERATURE VS OUTPUT CURRENT AND HV AT 25C AMBIENT

The curves below use the amplifier power dissipation information and the thermal resistance of 12 ºC/W without any heatsink or forced-air cooling to show quickly if a heatsink or forced-air cooling will be required.
When output current is known, draw a vertical line to the curve of the supply voltage (HV) that's closes to the HV in use and mark the spot where they intersect. If the point is above the 70C line on the chart, then either a heatsink or forced-air cooling will be required. If this is the case, then use the following curves for power dissipation and thermal resistance to determine what combination of heatsinking and/or cooling would be required.

BTM-055-20



BTM-090-10

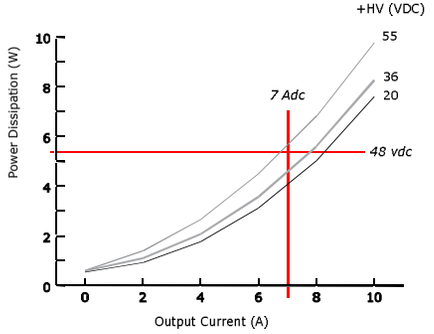


HEATSINK AND FORCED-AIR COOLING: HOW TO FIND OUT IF THESE ARE REQUIRED

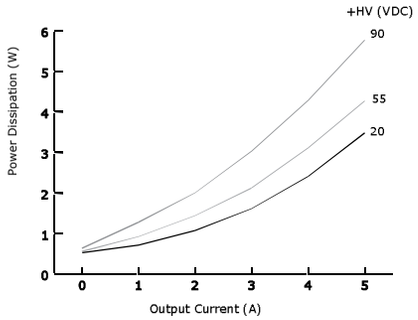
To see if a heatsink or fan-cooling is required, find the temperature rise the drive will experience when it's installed. For example, if the ambient temperature in the drive enclosure is 40 ºC, and the heatplate temperature is to be limited to 70º C or less to avoid shutdown, the maximum rise would be 70C - 40C. or 30C. Then find the power dissipation in the charts below. Divide the temperature rise by the power dissipation and the result is thermal resistance in ºC/W. Find this value on the Y-axis of the charts on the following page and draw horizontal lines across the charts to show what combinations of heatsink and air movement will produce this thermal resistance.

POWER DISSIPATION VS. OUTPUT CURRENT AND HV

BTM-055-20



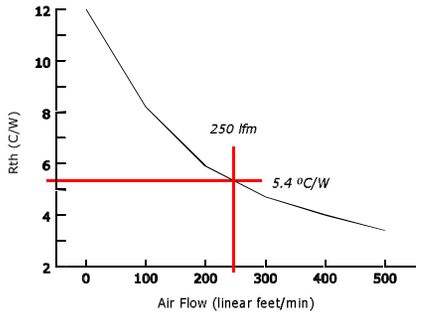
BTM-090-10



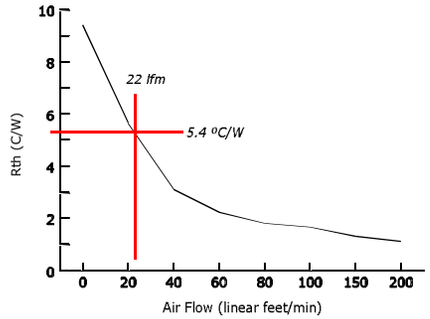
THERMAL RESISTANCE

The temperature rise of the amplifier when operating depends on the power dissipation and the thermal resistance between the amplifier and the environment.

NO HEATSINK



WITH HEATSINK



EXAMPLE

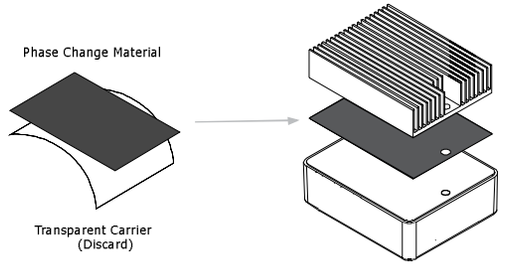
A BTM-055-20 application needs to output 7 Adc while operating from a 48 V power supply. In the chart on p. 10, place a vertical line at the 7 Adc point. Next draw a horizontal line that intersects it at a point 2/3 of the way between the 36 & 55 V curves, estimating a 48 Vdc power supply. This line yields a power dissipation of 5.4 W. Next, draw lines at the 5.4 ºC/W point on the curves above. These show that adding a heatsink reduces the air circulation requirement from 250 lfm to ~25 lfm. This low value can probably be met using a single fan in the enclosure to circulate air where it could cool multiple Bantam amplifiers adequately.

HEATSINK INSTALLATION

If a heatsink is used it is mounted using the same type of screws used to mount the drive without a heatsink but slightly longer. Phase change material (PSM) is used in place of thermal grease. This material comes in sheet form and changes from solid to liquid form as the drive warms up. This forms an excellent thermal path from drive heatplate to heatsink for optimum heat transfer.

STEPS TO INSTALL

1. Remove the PSM (Phase Change Material) from the clear plastic carrier.
2. Place the PSM on the *Bantam* aluminum heatplate taking care to center the PSM holes over the holes in the drive body.
3. Mount the heatsink onto the PSM again taking care to see that the holes in the heatsink, PSM, and drive all line up.
4. Torque the #4-40 mounting screws to 8~10 lb-in (0.9~1.13 N·m).



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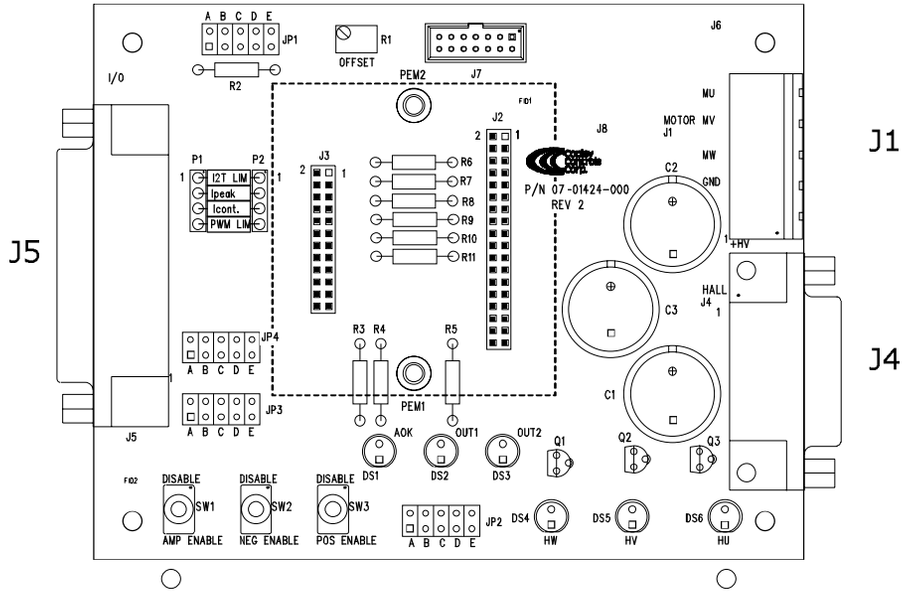
DEVELOPMENT KIT TOP VIEW

The graphic below shows the placement of components and connectors on the Development Kit PC board.
The Bantam amplifier is not shown, but mounts in the outline that contains connectors J3 & J2.



SOCKETED COMPONENTS

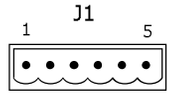
P1/P2	Remarks
1	I2T Time setting resistor
2	Ipeak setting resistor
3	Icont setting resistor
4	No function

CONNECTORS

These charts show the pins and signals for the Development Kit connectors.

J1 MOTOR AND HV POWER

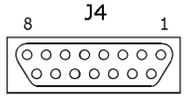
Pin	Signal
5	Mot U
4	Mot V
3	Mot W
2	HV Gnd
1	+HV Input



Euro 5 position

J4 HALLS

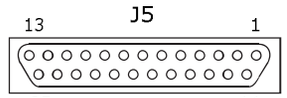
Signal	Pin		Signal
Sgnd	1	9	n.c.
Hall U	2	10	Sgnd
Hall V	3	11	+5 Vdc output
Hall W	4	12	Sgnd
Sgnd	5	13	n.c.
n.c.	6	14	n.c.
n.c.	7	15	n.c.
n.c.	8		



D-Sub 15 female

J5 CONTROL

Signal	Pin		Signal
Sgnd	1	14	Ref(-)
Ref(+)	2	15	Sgnd
Ext Balance	3	16	Sgnd
/NegEnab	4	17	/PosEnab
/Enable	5	18	Gain Select
[OUT1]	6	19	Sgnd
Current Cont Limit	7	20	n.c.
Current Ref	8	21	Curr Peak Limit
I2T Time	9	22	[AOK]
Current Monitor	10	23	+5 Vdc Output
[OUT2]	11	24	n.c.
Sgnd	12	25	n.c.
Sgnd	13		



D-Sub 25 female

NOTES

1) The combined current from J4-11 and J5-23 cannot exceed 250 mA.

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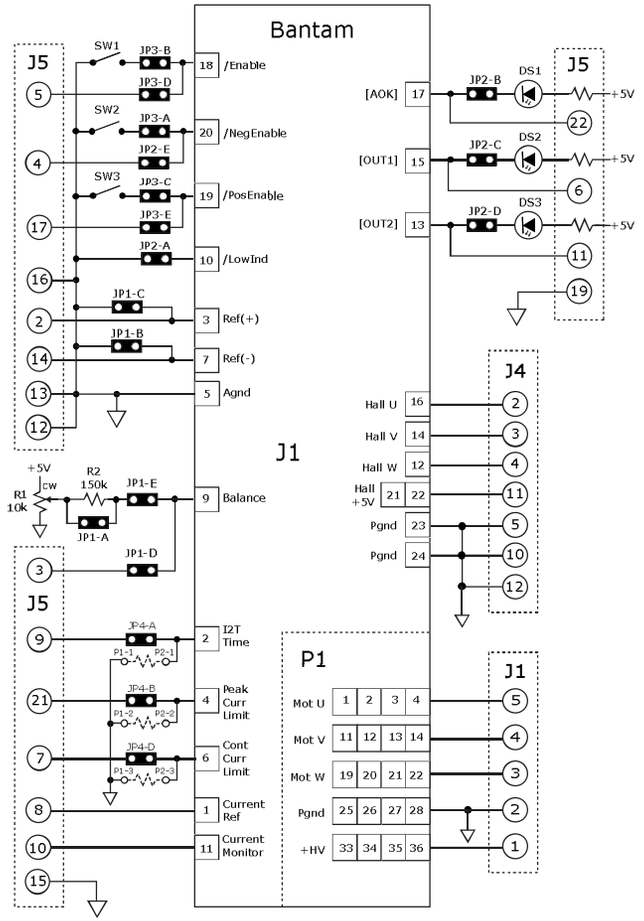
CONNECTIONS

In the diagram below, connectors inside the Bantam outline are the amplifier connectors, their signal names, and pin numbers. All connectors and components outside of the Bantam are on the Development Kit.



NOTES

1) The combined current from J4-11 and J5-23 cannot exceed 250 mA.

JUMPER FUNCTIONS

The functions shown in the tables below are in effect when the jumper is in place.
When a jumper is removed, the stated function is disabled.
J5 connects to an external controller

JP1

JP1	Remarks
A	Shorts 150k balance scaler
B	Ref(-) input is grounded
C	Ref(+) input is grounded
D	Connects J5-3 to Amp: Balance
E	R1 controls Amp: Balance

JP2

JP2	Remarks
A	Gain Select to Sgnd
B	Amp: [AOK] drives DS1
C	Amp: [OUT1] drives DS2
D	Amp: [OUT2] drives DS3
E	Connects J5-4 to Amp: /NegEnab

JP3

JP3	Remarks
A	Connects SW2 to Amp: /NegEnab
B	Connects SW1 to Amp: /Enable
C	Connects SW3 to Amp: /PosEnab
D	Connects J5-5 to Amp: /Enable
E	Connects J5-17 to Amp: /PosEnab

JP4

JP4	Remarks
A	Connects J5-9 to Amp: I2T Time
B	Connects J5-21 to Amp: Current Peak Limit
C	No connections
D	Connects J5-7 to Amp: Current Cont Limit
E	Connects J5-18 to Amp: Gain Select

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Bantam

Trapezoidal Torque Amplifier Module

RoHS CE

MASTER ORDERING GUIDE

BTM-055-20	*Bantam* analog current amplifier, 10/20 Adc
BTM-090-10	*Bantam* analog current amplifier, 5/10 Adc
BDK-090-01	Development kit
BDK-CK	Connector Kit for Development Kit

ORDERING EXAMPLE

Example: Order 1 BTM-055-20 current amplifier and development kit:

Qty	Item	Remarks
1	BTM-055-20	*Bantam* current amplifier
1	BDK-090-01	Development Kit for Bantam amplifier
1	BDK-CK	Connector Kit for Development Kit

ACCESSORIES

ORDER NUMBER	Qty	Ref	DESCRIPTION
BDK-CK Connector kit for BDK-090-01 Development Kit (includes next 5 items shown below)			
	1	J1	Connector, RoHS, Euro style plug, 5 position, Tyco (AMP) 796635-5
	1	J4	Connector, D-Sub, 15-position, male, RoHS, Tyco (AMP) 5-747908-2
	1	J4	Backshell, D-Sub, RoHS, metallized, 15-position, Norcomp 979-015-020R121
	1	J5	Connector, D-Sub, 25-position, male, RoHS, Tyco (AMP) 5-747912-2
	1	J5	Backshell, D-Sub, RoHS, metallized, 25-position, Norcomp 979-025-020R121

HEATSINK (OPTIONAL)

Heatsink Kit BTM-HK	1	Heatsink kit (for field-installation by customer)
	1	Heatsink Thermal Phase-change Material
	4	Heatsink hardware (#4-40 screws)

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Copley Controls

MODEL 503
DC BRUSHLESS SERVO AMPLIFIER

±50 Volts output at ±10A Peak, ±5A Continuous

FEATURES

- Complete torque (current) mode functional block
- Drives motor with 60° or 120° Halls
- Single supply voltage 18-55VDC
- 5A continuous, 10A peak more than double the power output of servo chip sets
- Fault protected
  Short-circuits from output to output, output to ground
  Over/under voltage
  Over temperature
  Self-reset or latch-off
- 2.5kHz bandwidth
- Wide load inductance range 0.2 to 40 mH.
- +5, +15V Hall power
- Separate continuous, peak, and peak-time current limits
- Surface mount technology

APPLICATIONS

- X-Y stages
- Robotics
- Automated assembly machinery
- Component insertion machines

THE *OEM* ADVANTAGE

- NO POTS: Internal component header configures amplifier for applications
- Conservative design for high MTBF
- Low cost solution for small brushless motors to 1/3 HP

Model 503

PRODUCT DESCRIPTION

Model 503 is a complete pwm servoamplifier for applications using DC brushless motors in torque (current) mode. It provides six-step commutation of three-phase DC brushless motors using 60° or 120° Hall sensors on the motor, and provides a full complement of features for motor control. These include remote inhibit/enable, directional enable inputs for connection to limit switches, and protection for both motor and amplifier.

The /Enable input has selectable active level (+5V or gnd) to interface with most control cards.

/Pos and /Neg enable inputs use fail-safe (ground to enable) logic.

Power delivery is four-quadrant for bi-directional acceleration and deceleration of motors.

Model 503 features 500W peak power output in a compact package using surface mount technology.

An internal header socket holds components which configure the various gain and current limit settings to customize the 503 for different loads and applications.

Separate peak and continuous current limits allow high acceleration without sacrificing protection against continuous overloads. Peak current time limit is settable to match amplifier to motor thermal limits.

Header components permit compensation over a wide range of load inductances to maximize bandwidth with different motors.

Package design places all connectors along one edge for easy connection and adjustment while minimizing footprint inside enclosures.

High quality components and conservative ratings insure long service life and high reliability in industrial installations.

A differential amplifier buffers the reference voltage input to reject common-mode noise resulting from potential differences between controller and amplifier grounds.

Output short circuits and heatplate overtemperature cause the amplifier to latch into shutdown. Grounding the reset input will enable an auto-reset from such conditions when this feature is desired.

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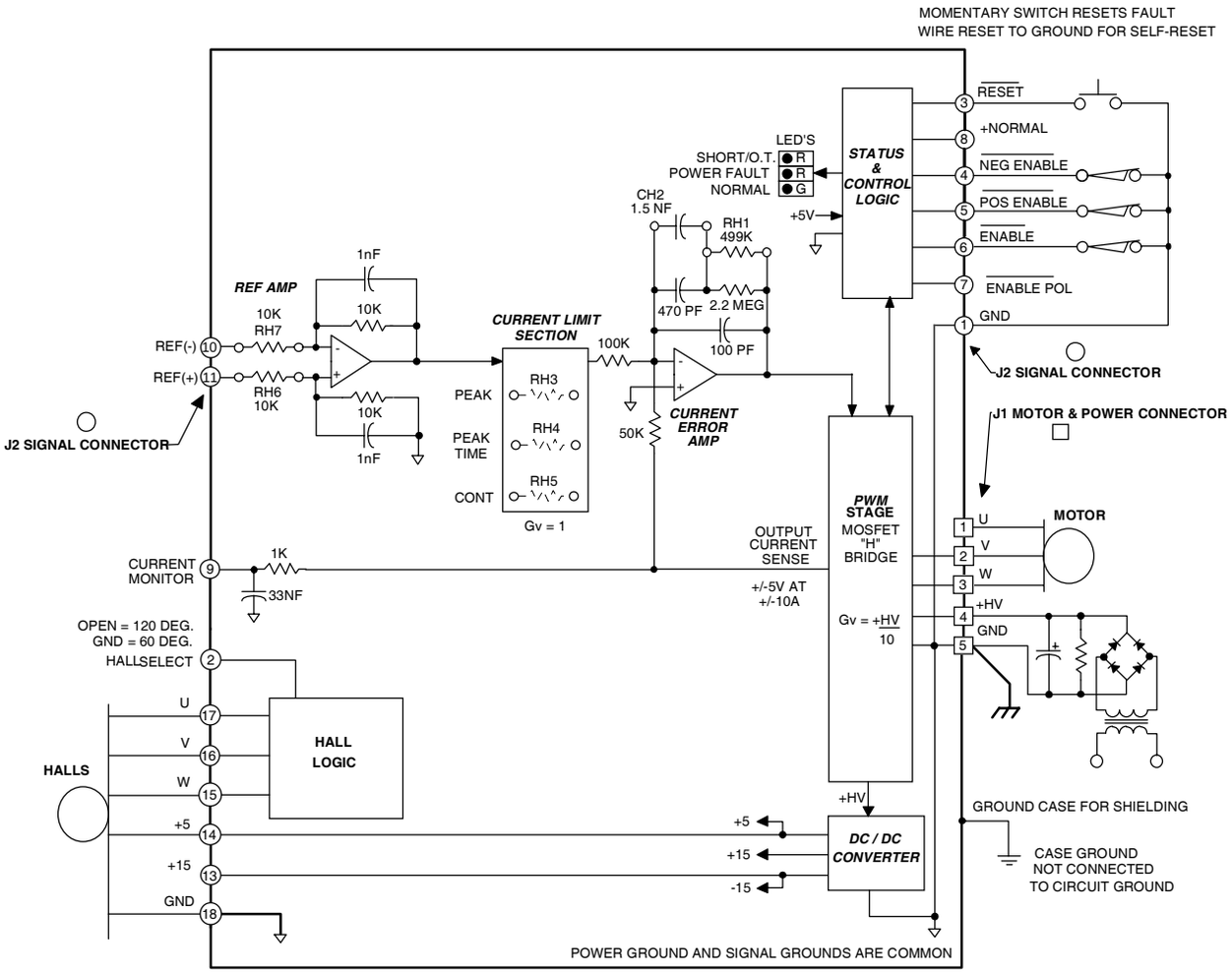
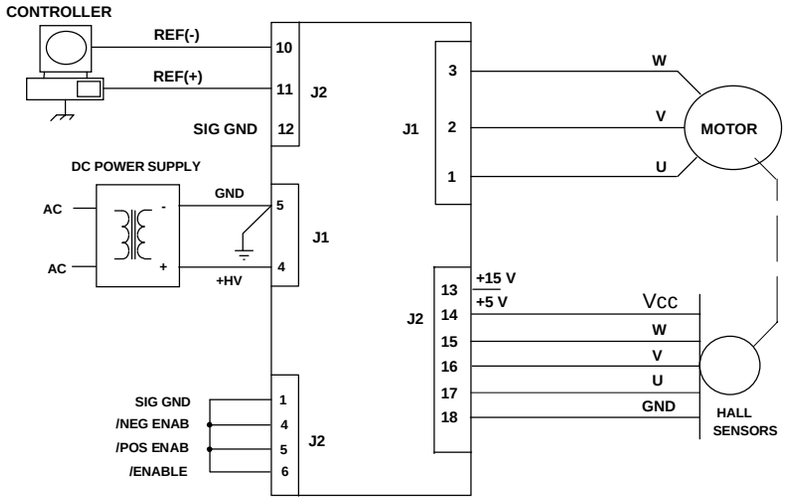
MODEL 503
DC BRUSHLESS SERVO AMPLIFIER

FUNCTIONAL DIAGRAM



TYPICAL CONNECTIONS



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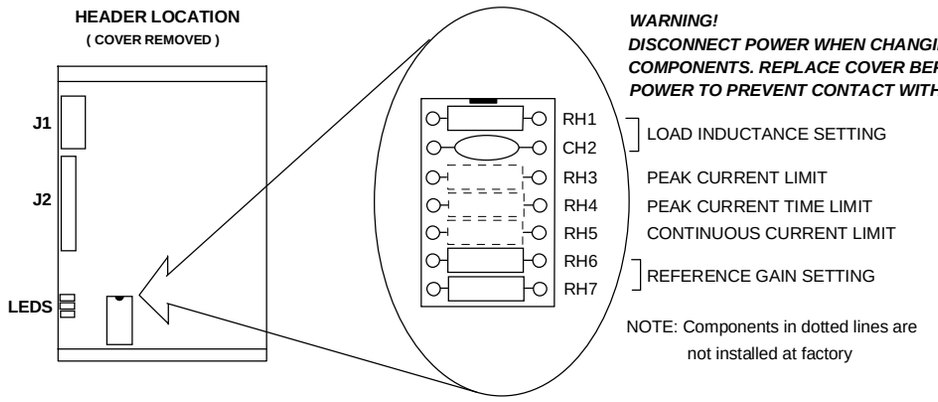
APPLICATION INFORMATION (CONT'D)

COMPONENT HEADER



WARNING!
DISCONNECT POWER WHEN CHANGING HEADER COMPONENTS. REPLACE COVER BEFORE APPLYING POWER TO PREVENT CONTACT WITH LIVE PARTS.

INPUT TO OUTPUT GAIN SETTING (RH6, RH7)

$$GAIN\ \frac{(A)}{(V)} = \frac{10}{RH\ 6}\ \frac{(k\Omega)}{(k\Omega)}$$ Note 1

Example: Standard value of RH6 is 10kΩ, thus G = 1 A/V

LOAD INDUCTANCE SETTING (RH1 & CH2) Note 2

Load (mH)	RH1	CH2
0.2	49.9 k	1.5 nF
1	150 k	1.5 nF
3	***499 k***	***1.5 nF ****
10	499 k	3.3 nF
33	499 k	6.8 nF
40	499 k	10 nF

PEAK CURRENT LIMIT (RH3) Note 3

Ipeak (A)	RH3 (Ω)
10	***open ****
8	12k
6	4.7k
4	2k
2	750

PEAK CURRENT TIME-LIMIT (RH4) Note 4

Tpeak (s)	RH4 (Ω)
0.5	***open ****
0.4	10 M
0.2	3.3 M
0.1	1 M

Times shown are for 10A step from 0A

Notes:

**** Standard values installed at factory are shown in italics.***

1. RH6 & RH7 should be 1% resistors of same value.
2. Bandwidth and values of RH1, CH2 are affected by supply voltage and load inductance. Final selection should be based on customer tests using actual motor at nominal supply voltage.
3. Peak current setting should always be greater than continuous current setting.
4. Peak times will double when current changes polarity. Peak times decrease as continuous current increases.

CONTINUOUS CURRENT LIMIT (RH5)

Icont (A)	RH5 (Ω)
5	***open ****
4	20k
3	8.2k
2	3.9k
1	1.5k

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Copley Controls

MODEL 503
DC BRUSHLESS SERVO AMPLIFIER

TECHNICAL SPECIFICATIONS

Typical specifications @ 25°C ambient, +HV = +55VDC. Load = 200µH. in series with 1 ohm unless otherwise specified.

OUTPUT POWER		
	Peak power	
	Unidirectional	±10A @ 50V for 0.5 second, 500W
	After direction change	±10A @ 50V for 1 second, 500W
	Continuous power	±5A @ 50V, 250W
OUTPUT VOLTAGE		Vout = 0.97HV -(0.4)(Iout)
MAXIMUM CONTINUOUS OUTPUT CURRENT		
	Convection cooled, no conductive cooling	±2A @ 35°C ambient
	Mounted on narrow edge, on steel plate, fan-cooled 400 ft/min	±5A @ 55°C
LOAD INDUCTANCE		
	Selectable with components on header socket	200 µH to 40mH (Nominal, for higher inductances consult factory)
BANDWIDTH		
	Small signal	-3dB @ 2.5kHz with 200µH load
	Note: actual bandwidth will depend on supply voltage, load inductance, and header component selection	
PWM SWITCHING FREQUENCY		
		25kHz
ANALOG INPUT CHARACTERISTICS		
	Reference	Differential, 20K between inputs with standard header values
GAINS		
	Input differential amplifier	X1 as delivered. Adjustable via header components RH6, RH7
	PWM transconductance stage	1 A/V (output vs. input to current limit stage)
OFFSET		
	Output offset current (0 V at inputs)	20 mA max. (0.2% of full-scale)
	Input offset voltage	20 mV max (for 0 output current, RH6,7 = 10kΩ)
LOGIC INPUTS		
	Logic threshold voltage	HI: ≥ 2.5V , LO: ≤1.0V, ***+5V Max on all logic inputs***
	/Enable	LO enables amplifier (/Enable Pol open) , HI inhibits; 50 ms turn-on delay
	/POS enable, /NEG enable	LO enables positive and negative output currents, HI inhibits
	/Reset	LO resets latching fault condition, ground for self-reset every 50 ms.
	/Enable Pol (Enable Polarity)	LO reverses logic of /Enable input only (HI enables unit, LO inhibits)
LOGIC OUTPUTS		
	+Normal	HI when unit operating normally, LO if overtemp, output short, disabled, or power supply (+HV) out of tolerance HI output voltage = 2.4V min at -3.2 mA max., LO output voltage = 0.5V max at 2 mA max. ***Note: Do not connect +Normal output to devices that operate > +5V***
INDICATORS (LED's)		
	Normal (green)	ON = Amplifier enabled, no shorts or overtemp, power within limits
	Power fault (red)	ON = Power fault: +HV <18V OR +HV > 55V
	Short/Overtemp (red)	ON = Output short-circuit or over-temperature condition
CURRENT MONITOR OUTPUT		±5V @ ±10A (2A/volt), 10kΩ, 3.3nF R-C filter
DC POWER OUTPUTS		
	+5VDC	30mA (Includes power for Hall sensors)
	+15VDC	10mA
		Total power from all outputs not to exceed 200mW.
PROTECTION		
	Output short circuit (output to output, output to ground)	Latches unit OFF (self-reset if /RESET input grounded)
	Overtemperature	Shutdown at 70°C on heatplate (Latches unit OFF)
	Power supply voltage too low (Undervoltage)	Shutdown at +HV < 18VDC (operation resumes when power >18VDC)
	Power supply voltage too high (Overvoltage)	Shutdown at +HV > 55VDC (operation resumes when power <55VDC)
POWER REQUIREMENTS		
	DC power (+HV)	+18-55 VDC @ 10A peak.
	Minimum power consumption	2.5 W
	Power dissipation at 5A output, 55VDC supply	10W
	Power dissipation at 10A output, 55VDC supply	40W
THERMAL REQUIREMENTS		
	Storage temperature range	-30 to +85°C
	Operating temperature range	0 to 70°C baseplate temperature
MECHANICAL		
	Size	3.27 x 4.75 x 1.28 in. (83 x 121 x 33mm)
	Weight	0.52 lb (0.24 kg.)
CONNECTORS		
	Power & motor	Weidmuller: BL-125946; Phoenix: MSTB 2.5/5-ST-5.08
	Signal & Halls	Molex: 22-01-3167 housing with 08-50-0114 pins

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Copley Controls

MODEL 503
DC BRUSHLESS SERVO AMPLIFIER

APPLICATION INFORMATION

To use the model 503 set up the internal header with the components that configure the transconductance, current limits, and load inductance. Current-limits and load inductance set up the amplifier for your particular motor, and the transconductance defines the amplifiers overall response in amps/volt that is required by your system.

COMPONENT HEADER SETTINGS

Use the tables provided to select values for your load and system. We recommend that you use these values as starting points, adjusting them later based on tests of the amplifier in your application.

LOAD INDUCTANCE (RH1,CH2)

Maximizes the bandwidth with your motor and supply voltage. First replace CH2 with a jumper (short). Adjust the value of RH1 using a step of 1A or less so as not to experience large signal slew-rate limiting. Select RH1 for the best transient response (lowest risetime with minimal overshoot). Once RH1 has been set. choose the smallest value of CH2 that does not cause additional overshoot or degradation of the step response.

TRANSCONDUCTANCE (RH6,7)

The transconductance of the 503 is the ratio of output current to input voltage. It is equal to 10kΩ/RH6 (Amps/Volt). RH6,and RH7 should be the same value and should be 1% tolerance metal film type for good common-mode noise rejection.

CURRENT LIMITS (RH3, 4, & 5)

The amplifier operates at the 5A continuous, 10A peak limits as delivered. To reduce the limit settings, choose values from the tables as starting points, and test with your motor to determine final values. Limit action can be seen on current monitor when output current no longer changes in response to input signals. Separate control over peak, continuous, and peak time limits provides protection for motors, while permitting higher currents for acceleration.

SETUP BASICS

1. Set RH1 and CH2 for motor load inductance (see following section).
2. Set RH3, 4, & 5 if current limits below standard values is required.
3. Ground the /Enable (/Enable Pol open), /Pos Enable, and /Neg Enable inputs to signal ground.
4. Connect the motor Hall sensors to J2 based on the manufacturers suggested signal names. Note that different manufacturers may use A-B-C, R-S-T, or U-V-W to name their Halls. Use the required Hall supply voltage (+5 or +15V). *Note that there is a 30 mA limit at +5V. Encoders that put-out Hall signals typically consume 200-300 mA, so if these are used, then they must be powered from an external power supply.*
5. Connect J1-4,5 to a transformer-isolated source of DC power, +18-55V. Ground the amplifier and power supply with an additional wire from J1-5 to a central ground point.
6. With the motor windings disconnected, apply power and slowly rotate the motor shaft. Observe the Normal (green) led. If the lamp blinks while turning then the 60/120° setting is incorrect. If J2-2 is open, then ground it and repeat the test. In order to insure proper operation, the correct Hall phasing of 60° or 120° must be made.
6. Turn off the amplifier and connect the motor leads to J1-1,2,3 in U-V-W order. Power up the unit. Apply a sinusoidal reference signal of about 1 Hz. and 1Vrms between Ref(+) and Ref(-), J2-10,11.
7. Observe the operation of the motor as the current monitor signal passes through zero. When phasing is correct the speed will be smooth at zero crossing and at low speeds. If it is not, then power-down and re-connect the motor.

There are six possible ways to connect the motor windings, and only one of these will result in proper motor operation. The six combinations are listed in the table below. Incorrect phasing will result in erratic operation, and the motor may not rotate. When the correct combination is found, record your settings.

	J1-1	J1-2	J1-3
#1	U	V	W
#2	V	W	U
#3	W	U	V
#4	U	W	V
#5	W	V	U
#6	V	U	W

GROUNDING & POWER SUPPLIES

Power ground and signal ground are common (internally connected) in this amplifier. These grounds are isolated from the amplifier case which can then be grounded for best shielding while not affecting the power circuits. Currents flowing in the power supply connections will create noise that can appear on the amplifier grounds. This noise will be rejected by the differential amplifier at the reference input, but will appear at the digital inputs. While these are filtered, the lowest noise system will result when the power-supply capacitor is left floating, and each amplifier is grounded at its power ground terminal (J1-5). In multiple amplifier configurations, always use separate cables to each amplifier, twisting these together for lowest noise emission. Twisting motor leads will also reduce radiated noise from pwm outputs. If amplifiers are more than 1m. from power supply capacitor, use a small (500-1000μF.) capacitor across power inputs for local bypassing.

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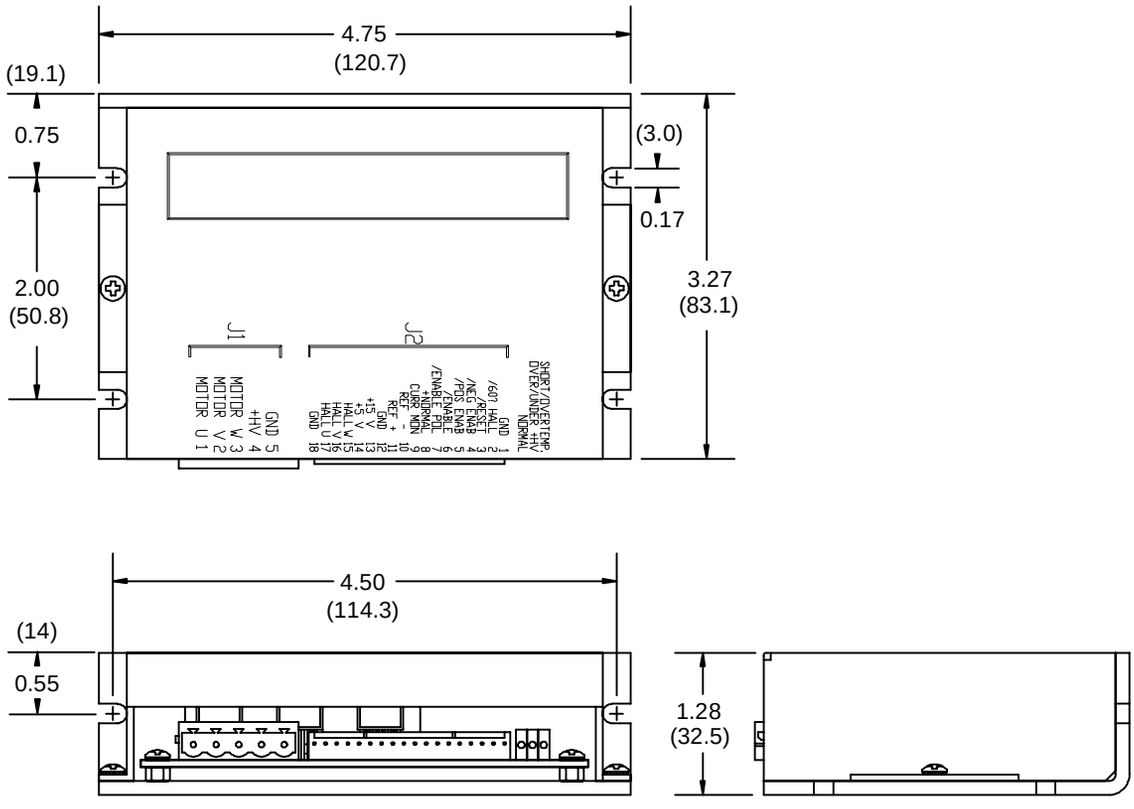
MODEL 503
DC BRUSHLESS SERVO AMPLIFIER

OUTLINE DIMENSIONS

Dimensions in inches (mm.)



ORDERING GUIDE

Model 503	5A Continuous, 10A Peak, +18-55VDC Brushless Servoamplifier

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MODELS 7225AC, 7425AC
LINE-POWERED AC BRUSHLESS SERVO AMPLIFIERS WITH ±10V ANALOG U-V INPUTS

FEATURES

- **Complete line-powered servo amplifier for AC brushless motors with external sinusoidal commutation**
- **Off-the-line powered: 32~132VAC, 32~264VAC 50/60Hz, single-phase *No transformer required***
- **Optically isolated power and signal stages**
- **Separate motor and signal Sub-D type connectors**
- ***FAIL-SAFE ENABLE INPUT***
  Ground or +5V active level selection
- ***FAULT PROTECTIONS***
  Short-circuits
  output to output
  output to ground
  Over / under voltage
  Over temperature
  Self-reset or latch-off
- ***CURRENT LIMIT***
  With no loss of Phasing and alert signal for control system
- **3kHz Bandwidth**
- **Wide load inductance range 0.4~ 40 mH.**

WORKS WITH POPULAR CONTROLLERS

- ***ACS-Tech80*** **5651A**
  ACS-Tech80 **SPiiPlus series**
- ***PMD*** **MC1231A Chipset**
- ***Delta Tau*** **PMAC**
- ***MEI*** **DPS Series**
- ***Galil*** **DMC-1700**

THE OEM ADVANTAGE

- **Internal header configures amplifier for plug and play operation**
- **Conservative design for high MTBF**

MODEL	POWER	I-CONT (A)	I-PEAK (A)
7225AC	32~132VAC	10	20
7425AC	32~264VAC	10	20

FEATURES

The 7xx5AC models are PWM servoamplifiers for AC brushless servomotors that are commutated externally by digital control systems that output two +/-10V signals that represent the current command to the motor U and V windings. The amplifier then synthesizes the current command for the W winding.

Control cards take feedback from an encoder on the motor and use various techniques to determine the rotor position. When this has been done, the controller is able to output two signals that correspond to the current in the U and V windings to produce torque in the motor. The amplifier synthesizes the W winding current from UV signals that are either 120 or 90 electrical degrees apart.

Amplifier adjustments with this system consist of inductance compensation, current limit, transconductance, and offset. Thereafter, the controller does all of the velocity and/or position control of the motor.

An internal 40-pin solderless socket lets the user configure the various gain and current limit settings to customize the amplifiers for a wide range of loads and applications. Header components permit compensation over a wide range of load inductance's to maximize bandwidth with different motors.

Current limiting is provided via an internal solderless header socket or by an external resistance or voltage applied to the signal connector.

The /Enable input active logic-level is switch-selectable to ground or +5V to interface with all types of control cards. Fail-safe operation in either polarity results from an internal jumper that selects the default input level and input resistor pull-up or pull-down connections so that the amplifier shuts down with no input.

MOSFET (7225AC) and IGBT (7425AC) output stages deliver four-quadrant power for bi-directional acceleration and deceleration of motors. For high-inertia loads, an external regenerative energy dissipater is available.

All models are protected against output short circuits (output to output and output to ground) and heatplate overtemperature. With the /Reset input open the amplifier will latch off until powered-down or the /Reset input is toggled. The amplifier will reset itself automatically from faults if the /Reset input is wired to GND.

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MODELS 7225AC, 7425AC
LINE-POWERED AC BRUSHLESS SERVO AMPLIFIERS WITH +/-10V ANALOG U-V INPUTS

TECHNICAL SPECIFICATIONS

MODEL			7225AC	7425AC
OUTPUT POWER				
	Peak power		20 A @ 110V	20 A @ 205V
	Peak time		2 sec at peak power independent of polarity reversal	
	Continuous power		10 A @ 130V	10 A @ 250V
OUTPUT VOLTAGE				
	On-resistance (Ro, ohms)		0.2	0.15
	Max PWM Peak Output Voltage		±Vout = (VAC X 1.41 -2)×(0.97) - (Ro)×(Io)	
INPUT POWER				
	Mains voltage		32~132VAC, 47~63Hz	32~264VAC, 47~63Hz
	Mains current @ continuous output rating		16 A	16 A
	Inrush current on startup		19 A.	37 A.
	External mains fuse rating		20 A/125V	20 A/250V
LOAD INDUCTANCE				
	Minimum inductance		400 µH.	400 µH.
	Maximum inductance		No maximum. See chart of load inductance values. Bandwidth varies with inductance and header parts.	
BANDWIDTH	Small signal		-3dB @ 3kHz with minimum load at nominal supply voltage. Varies with load inductance and header values	
PWM OUTPUTS				
	PWM frequency		25kHz	
	Modulation		Carrier-cancellation, 50% duty cycle at 0V output	
REFERENCE INPUT			Differential, 94kΩ max. to 47kΩ min. between inputs, ±20V maximum	
POTENTIOMETERS	U Ref Fine Gain (R1)	Default = Center	CCW attenuates U Reference.	
	V Ref Fine Gain (R2)	Default = Center	CCW attenuates V Reference.	
	(Internal)			
	U phase current Zero (R7)		Adjusts U output current to zero with U and V inputs = 0V.	
	V phase current Zero (R6)		Adjusts V output current to zero with U and V inputs = 0V.	
DIPSWITCH				
	S1	/Enable input active polarity.	OFF (default): Gnd enables amplifier, open or +5V inhibits. ON: Gnd inhibits, open enables	
UV PHASE SELECTION			Internal jumper JP1-A selects UV phase of 120° or 90° (Default = 120°)	
LOGIC INPUTS				
	/Enable	Default = GND	GND enables amplifier, open or >2.5V inhibits with S1 OFF. If S1 ON then GND inhibits See following section on fail-safe operation for JP1-B settings. Response time is 1 ms from enable active to amplifier output ON.	
	/Reset	Default = Open	GND resets latching fault condition, ground for self-reset every 50 ms.	
	/Motemp	Default = GND	Motor temperature sensor. Typically normally closed bimetal sensor. Open = overtemp	
	Input resistance		10kΩ to +5V, R-C filters on inputs	
	Logic threshold voltage		2.5V (Schmitt trigger inputs with hysteresis, 74HC14)	
	Input voltage range		0V to +32VDC	
FAIL-SAFE ENABLE INPUT				
	Internal jumper JP1-B selects +5V or GND connection for input pull-up resistors to /Enable input only so that amplifier will default to *disabled* condition if inputs are open-circuit, or wires are broken. (See Applications section for details)			
LOGIC OUTPUTS				
	/Normal		LO (current sinking) when status LED is green; HI when LED is red or blinking red / green.	
	HI output voltage		+5V (no load). Output is N-channel MOSFET drain terminal with10kΩ pull-up resistor to +5V	
	LO output voltage		On resistance Ro = 5Ω. Max sink current of 250 mA. max off-voltage = 50VDC	
	Amp OK		Buss volts OK AND NOT (output short OR overtemp)	
			N-channel opto-isolator is ON when amp is OK. ON current 4 mA min. Max voltage 32 VDC	
	/CLIMIT		HI when amplifier is not current limiting; LO when current is limit is reached.	
	HI output voltage		+5V (No load). Output is LM339 open collector with 10kΩ pull-up resistor to +5V	
	LO output voltage		Max sink current of 15 mA, max off voltage = 36VDC	
STATUS LED				
	Bicolor LED changes color and flashes to indicate amplifier operating status			
	Green = Normal		*Amplifier enabled* AND Amp OK (see above)	
	Blinking green = Ready		Amplifier OK, will *run* when enabled	
	Red = Fault, non-latching		Over or under-voltage condition or motor overtemp; Amplifier recovers when voltage or temp. is in normal range.	
	Blinking red = Latching Fault		Output overcurrent (short circuit) or amp. overtemp condition. Ground /Reset or power amp. off/on to clear condition	
CURRENT LIMIT INPUT				
	Current limit		0-5V controls current limiting (See application section for details)	
MONITOR OUTPUTS				
	Current Monitor U		Motor winding current in U phase: ±10V @ ±20 A or 2 A/V (1kΩ, 33nF R-C filter)	
	Current Monitor V		Motor winding current in V phase: ±10V @ ±20 A or 2 A/V (1kΩ, 33nF R-C filter)	
DC POWER OUTPUTS				
			+5V @ 200 mA max (J3-23) +10VDC @ 5 mA (J3-24) -10VDC @ 5 mA (J3-25) Note: maximum power from all DC outputs not to exceed 1.4W	

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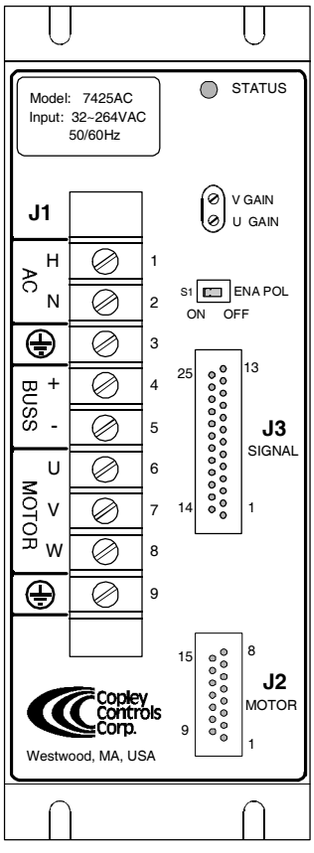
MODELS 7225AC, 7425AC
LINE-POWERED AC BRUSHLESS SERVO AMPLIFIERS WITH +/-10V ANALOG U-V INPUTS

PROTECTIVE FEATURES			
Short circuit (output to output, output to ground)	Latches unit OFF (Power off/on, or ground at /Reset input resets)		
OverTemperature	Latches unit OFF at 70°C on heatplate (Power off/on, or ground at /Reset input resets) *Wire /Reset input to ground for automatic reset after latching fault*		
Undervoltage	Shutdown at internal DC buss < 45VDC		
Overvoltage	Shutdown at internal DC buss > 195VDC (Model 7225AC), or internal DC buss > 390VDC (Model 7425AC) (Amplifier operation resumes when internal DC buss is NOT Undervoltage or NOT Overvoltage)		
Current-limiting	Output current set by header component or external voltage or resistance Current will fold-back to continuous rated current (10 A) after 2s maximum at 20 A Relative amplitude of U/V/W phase currents maintained for no loss of commutation		
AMPLIFIER DISSIPATION			
Watts minimum	17W (Model 7225AC)	7W (Model 7425AC)	
Watts @ continuous current	60W (Model 7225AC)	61W (Model 7425AC)	
THERMAL REQUIREMENTS			
Storage temperature range	-30°C to +85°C		
Operating temperature range	0° to 70°C baseplate temperature		
Thermal resistance (heatplate to ambient):	No heatsink or fan: 0.92 deg. C/W; no heatsink with fan: 0.51 deg. C/W With heatsink, no fan: 0.6 deg. C/W; with heatsink and fan: 0.23 deg. C/W		
MECHANICAL			
Size	7.50 x 6.94 x 2.72 in. (190 x 174 x 69 mm) without optional heatsink 7.50 x 6.94 x 4.72 in. (190 x 174 x 120 mm) with optional heatsink		
Weight	3.71 lbs. (1.69 kg) without optional heatsink. Add 3.2 lbs. (1.47 kg) for heatsink.		
CONNECTORS			
J1: Power & motor	9-position terminal strip		
J2: Motor temperature	15-position female Sub-D type. #4-40 standoffs for cable shell lock screws		
J3: Signal	25-position female Sub-D type. #4-40 standoffs for cable shell lock screws Connector shells are connected to amplifier chassis for grounding/shielding		

PANEL LAYOUT



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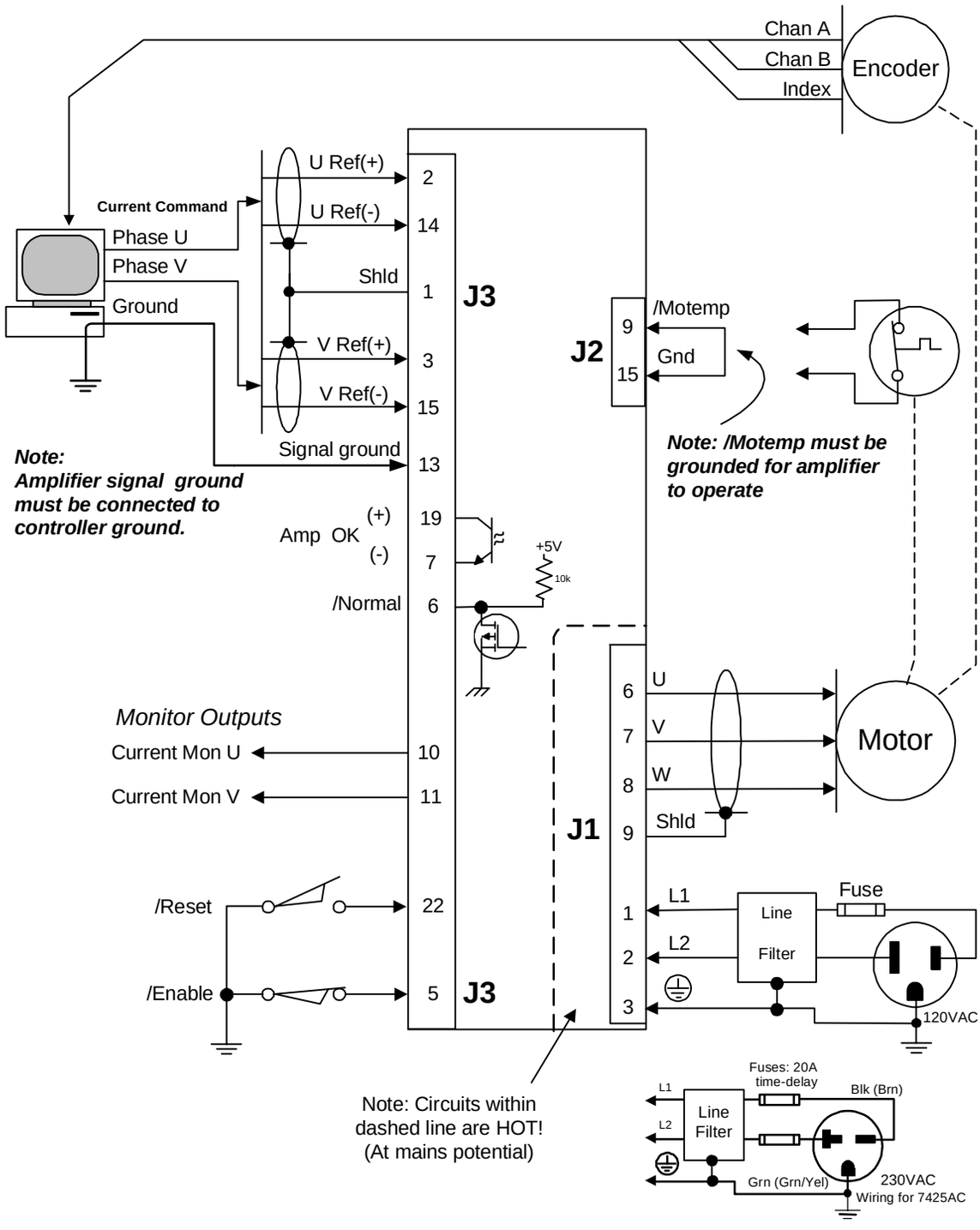
TYPICAL AMPLIFIER CONNECTIONS



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CONNECTORS

J1 POWER AND MOTOR WINDING CONNECTIONS

Connector type: Barrier-block. Screw-terminal connections. #6-32 locking screws with cable clamps.

PIN	SIGNAL	FUNCTION
1	L1	AC Power Input Hot (black or brown wire from AC mains)
2	L2	AC Power Input Neutral (white or blue wire from AC mains)
3	GND	Chassis safety ground (green or green/yel wire from AC mains)
4	Buss (+)	Positive terminal of internal DC power supply
5	Buss (-)	Negative terminal of internal DC power supply
6	Motor U	Amplifier output to "U" winding of motor
7	Motor V	Amplifier output to "V" winding of motor
8	Motor W	Amplifier output to "W" winding of motor
9	GND	Chassis safety ground. Also for cable shield of motor cable.

J2 MOTOR TEMPERATURE CONNECTIONS

Connector type: Female Sub-D, 15 position, #4-40 locking standoffs

PIN	SIGNAL	FUNCTION
1	Safety GND	Chassis ground. Use to ground cable shield. Not connected to internal signal ground.
2	N.C.	
3	N.C.	
4	N.C.	
5	N.C.	
6	N.C.	
7	N.C.	
8	N.C.	
9	Motemp	***Note: Must be grounded for amplifier to operate (Connect to J2-10,12,14, or 15)***
10	0V	Signal ground
11	N.C.	
12	0V.	Signal ground.
13	N.C.	
14	0V.	Signal ground.
15	0V.	Signal ground.

J3 SIGNAL CONNECTIONS

Connector type: Female Sub-D, 25-position, #4-40 locking standoffs

PIN	SIGNAL	FUNCTION	PIN	SIGNAL	FUNCTION
1	Safety GND (Case)	Chassis ground. Use to ground cable shield. Not connected to internal signal ground (J3-12, 13,16).			
2	U Ref (+)	Positive terminal of differential +/-10V analog command input	14	U Ref (-)	Negative terminal of differential +/-10V analog command input
3	V Ref (+)	Positive terminal of differential +/-10V analog command input	15	V Ref (-)	Negative terminal of differential +/-10V analog command input
4	N.C.		16	0V.	Signal ground.
5	/Enable input	Amplifier enable	17	N.C.	
6	/Normal output	Mosfet output amp status	18	N.C.	
7	Amp OK (-) output	Opto-isolator emitter (NPN)	19	Amp OK (+) output	Opto-isolator collector (NPN)
8	N.C.		20	Ext. I-limit	External setting of curr. limit
9	/CLIMIT	Current limit status	21	N.C.	
10	Current Monitor U	+/-10V @ +/-20 A	22	/Reset input	
11	Current Monitor V	+/-10V @ +/-20 A	23	+5V @ 200 mA.	Auxiliary DC power for user devices
12	0V.	Signal ground.	24	+10V @ 5 mA	Auxiliary DC power
13	0V.	Signal ground ***must be connected to the controller ground***	25	-10V @ 5 mA	Auxiliary DC power

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MODELS 7225AC, 7425AC
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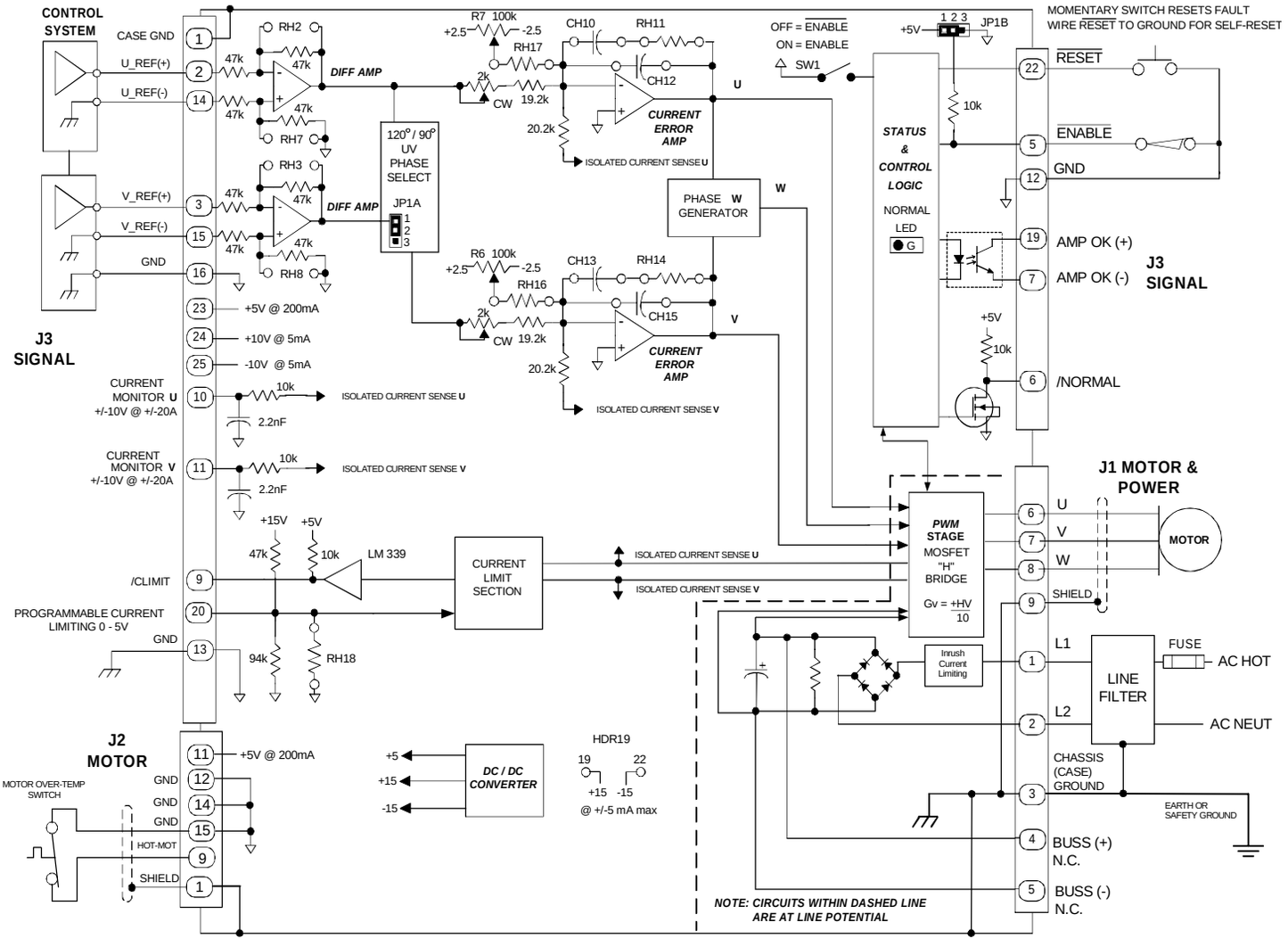
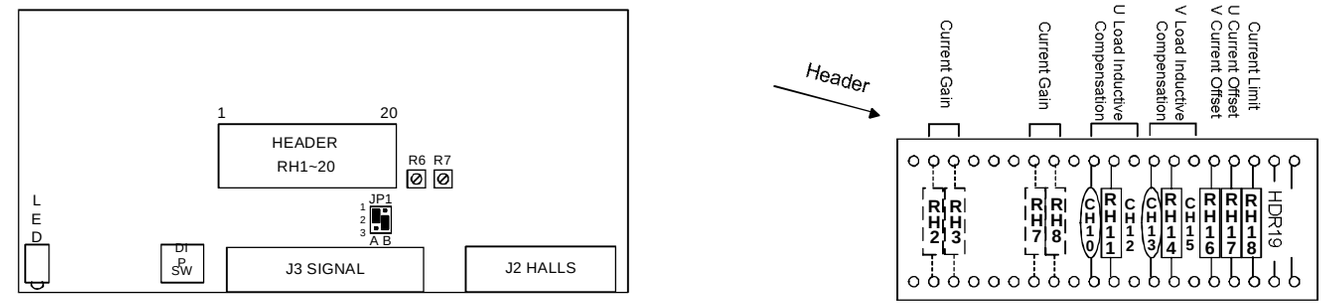
FUNCTIONAL DIAGRAM



SIGNAL BOARD AND HEADER SOCKET LAYOUT



The header socket holds components that determine the amplifier performance such as inductance compensation, offset scaling, and peak current limit. Components are named **RH**n, **CH**n as **R**esistor **H**eader n, **C**apacitor **H**eader n, etc. See applications section for details.

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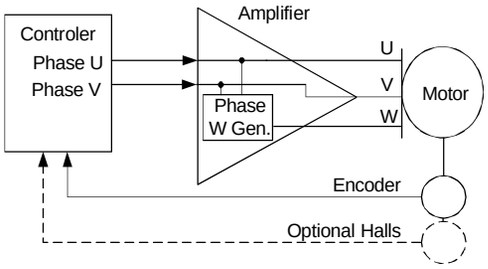
APPLICATION INFORMATION

EXTERNAL COMMUTATION OVERVIEW

The model 7XX5AC amplifiers are designed to work with controllers that perform external commutation to drive AC brushless motors. Lower torque ripple can be obtained by sinusoidal commutation of the three-phase motor than can be obtained by trapezoidal commutation. The figure below shows a typical external commutation configuration using an encoder for determining position. The controller uses two DAC outputs, the U and V Phase, to drive the U and V reference inputs on the amplifier. The amplifier then generates W Phase and delivers power to all three motor windings simultaneously.

The encoder data is processed by the controller, to generate the sinusoidal waveform signals, which are delivered to the amplifier. These waveforms are typically 120° phase separated, a jumper in the amplifier can be moved for 90° phase separation. The controller will perform a phase initialization routine for proper commutation. Improved phase initialization can be achieved by using Hall sensors for determining initial position.



AMPLIFIER WIRING & CABLING

Power supply and motor connections should be made with wire that has a rating to support the amplifiers continuous current. AWG 14 wire will support all amplifiers in this series. To minimize noise radiation from the motor and power cabling, wires should be twisted and shielded. Motor sensor signals are often routed near the motor phase winding cables. To minimize coupling of PWM noise, sensor signal wiring should be multiple-conductor-shielded cable.

GROUNDING AND ISOLATION

The signal board is fully isolated from the power section in this series of amplifiers. For proper operation, ***connect the signal ground J3-13 to the controller ground.***

For safety, it is important that J1-3 be connected to earth ground, typically through the power cable.
The connections on the power board, such as the motor phase, are at line potential.

SETUP FOR THE MOTOR

The motor windings and encoder are to be connected in accordance with the control card setup.

MOTOR INDUCTANCE COMPENSATION

Header components control the amplifier compensation for different motors. These set the gain in the current error amplifier to give the best response for different winding *inductance*. There are two current-control loops in this series of amplifiers, both must have the same values in the header. The tables below give values for the header parts for the two models. The default values for RH11 and RH14 are indicated below in bold & italic. If the inductance of your motor is less than ½ of the value shown in the table, use the values from the next *lower* inductance range. Ex., for a 4 mH motor, use the values from the 3 mH row (1/2 of 10mH is 5mH, which is greater than 4mH, so the value from the next *lower* row, 3mH, is used).

For all tables: CH12 & CH15 are <out>

Model 7225AC @ 115VAC; CH10 & CH13 = 15nF

L (mH)	R11& RH14 (kΩ)
0.3	18
1	***39***
3	75
10	180
30	300

Model 7425AC @ 230VAC; CH10 & CH13 = 10nF

L (mH)	R11& RH14 (kΩ)
0.3	12.5
1	***24.9***
3	51
10	120
30	200

Model 7425AC @ 115VAC CH10 & CH13 = 10nF

L (mH)	R11& RH14 (kΩ)
0.3	18
1	39
3	75
10	180
30	300

If the default values do not give sufficient bandwidth, contact factory for a detailed tuning procedure.

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MODELS 7225AC, 7425AC
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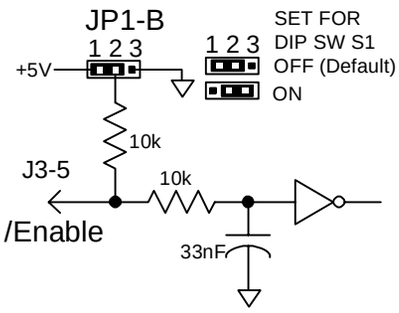
/ENABLE INPUT ACTIVE LEVEL CONTROL

DIP switch S1, ENAB POL, controls active level of the amplifier enable input at J3-5. The *default* position is S1 OFF, this will make the */Enable input ground-active, >2.5V will disable the amplifier.* With S1 ON, this will make the /Enable input disable amplifier if grounded, >2.5V will enable.

ON OFF (Default)

ENABLE INPUT FAIL SAFE CONTROL

Jumper JP1-B, on the signal board, controls the /Enable input level control resistor. The figure below shows the function, with S1 OFF and JP1-B on pins 1-2 as the default condition. The /Enable input must be pulled LO to enable the amplifier, and if the input is open (disconnected or wire broken) the amplifier turns off as the input is pulled-up to +5V. This is called *fail-safe* because the amplifier must be connected, and the input actively driven to ground to turn the amplifier ON, otherwise it's OFF.



If an active HI fail-safe operation is desired, then turn S1 ON and move JP1-B to pin 2-3. Now the input is *pulled-down* to ground if it is disconnected, and must be actively pulled-up to >2.5V by the control system to enable the amplifier.

U V PHASE ANGLE

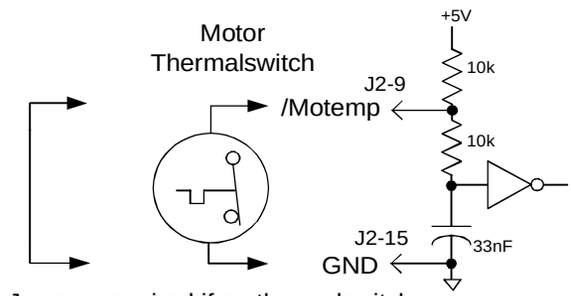
Jumper JP1-A, on the signal board, sets the UV phase to either 120° or 90°. The default is 120°.

JP1-A

1 2 3
120 Degrees UV Phase (Default)
90 Degrees UV Phase

MOTOR TEMPERATURE SENSOR

The /MOTEMP (J2-9) line must be pulled to GND (J2-15) in order to enable the amplifier. The figure below shows the function. A normally closed thermal switch can be connected to protect the motor from over temperature. When the switch opens the /MOTEMP line is pulled to +5V through a 10k resistor, disabling the amplifier.



Jumper required if no thermalswitch

REFERENCE INPUTS

The reference inputs are the command signals to the amplifier. There are two differential reference inputs U Ref (+), U Ref (-) and V Ref (+), V Ref (-) *Use all four reference wires.* Connect U Ref (-) and V Ref (-) to control system ground. Connect U Ref (+) and V Ref (+) to control system's separate ±10V outputs. This will reject noise between control system and amplifier grounds. Use twisted-pair cable to minimize noise pickup between amplifier and controller.

U V PHASE CURRENT ZERO ADJUSTMENT

BALANCE ADJUSTMENT RANGE

Control of the balance adjustment range can be made via internal components RH16 and RH17 on the header socket. The full-scale can be adjusted over a typical range of 500mA to 50mA. A good first approximation would be 5% of the motors continuous current rating. See below table, for selecting resistor values for RH16 and RH17. The default values are indicated in bold.

U V zero adjust full-scale RH16 & RH17

Offset full-scale mA	Rx (Ω)
500	200k
400	**250k**
300	330k
200	475k
100	1M
50	2.2M

These values are within 10%, typically. For greater accuracy, measure current monitor and select parts for exact full-scale value.

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MODELS 7225AC, 7425AC
LINE-POWERED AC BRUSHLESS SERVO AMPLIFIERS WITH +/-10V ANALOG U-V INPUTS

ZERO ADJUSTMENT

The current OFFSET potentiometers are factory set to zero current with zero input. The sum of the three currents U, V and W can be set to a high degree of resolution by using the current monitors. After connecting and tuning the motor, ground the U and V reference inputs, then adjust the offset potentiometer (see below table) while monitoring the appropriate current monitor U (J3-10) and V (J3-11) with respect to Ground (J3-13).

If the U and V currents are correctly set to zero then the W current will also be zero: Iw = - (Iu + Iv)

POT	DEFAULT	DESCRIPTION
U OFFSET (R7 internal)	Center	U zero output current adjustment
V OFFSET (R6 internal)	Center	V zero output current adjustment

TRANSCONDUCTANCE ADJUSTMENT OVERALL GAIN

The current gain or transconductance is the ratio of output current to input voltage. The transconductance should be set to provide a better use of the controllers output range, typically a +/10V DAC. The gain can be set via RH2, RH3, RH7, and RH8, see below table. All resistor values must be the same. Use 1% tolerance for good CMRR (common mode rejection ratio).

It is recommended that the transconductance be set to limit the peak current delivered to the motor. Most applications require peak currents of two or three times the motors continuous current rating. Example: For a typical +/-10V DAC and a required 15 Amps peak, the transconductance should be set to 15 Amps / 10 Volt = 1.5 Amps / Volt.

The Gain (Amps / Volt) = 2 * Rx Ω / (47kΩ + Rx Ω). The default gain is 2A/V with RH2, RH3, RH7, and RH8, resistors open or out of circuit. (Indicated in bold & italic in the table below).

Transconductance Rx = RH2,3,7 &, 8

Gain Amps/Volt	Rx (Ω)
2	***OPEN***
1.5	140k
1	47k
0.5	15.6k

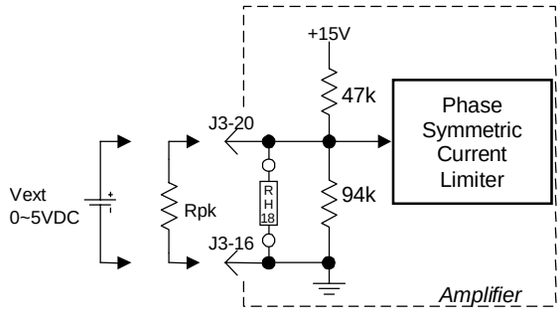
GAIN FINE ADJUSTMENT

The REF GAIN potentiometers are factory set to give a matched transconductance of 2Amps/Volt, with RH2, RH3, RH7, and RH8, resistors open or out of circuit. The gain of both U and V channels can be fine-tuned to match. The range is about +/-5%. To fine adjust the transconductance, input a reference voltage, such as 1VDC, to the U Ref (+) (J3-2) and V Ref (+) (J3-3), Remembering to ground Ref (-) (J3-14, J3-15) at the source. Then while monitoring the appropriate current monitor, adjust the REF GAIN potentiometers to match.

POT	DEFAULT	DESCRIPTION
U REF GAIN (R1)	Center	U Fine gain control CW increases gain
V REF GAIN (R2)	Center	V Fine gain control CW increases gain

CURRENT LIMIT

Control of the current limit can be made internally via component RH18 in the header socket, or externally via connector pin J3-20. See figure below.
A resistor can be connected between this pin and signal ground (J3-12, 13, or 16), or the pin can be driven by a voltage between 0 and +5VDC. Using this technique, the current limit can be controlled over a range of 100% to 50% of the peak command current, set by the transconductance.



CURRENT LIMIT (RH18)
Default values are in bold & italic.

I-limit	RH18	Vext
10	***31.6k***	***5***
8	16.9k	3.5
6	10.5k	2.5
4	5k	1.4
2	1.3k	0.4

These values are within 10%, typically. For greater accuracy, measure current monitor and select parts for exact limit value.

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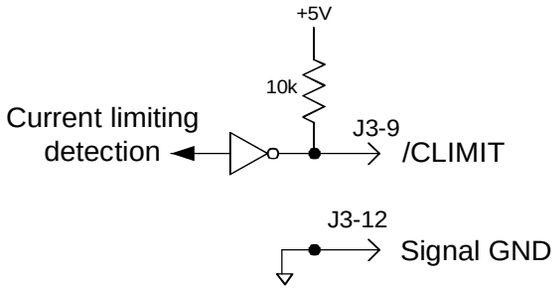
STATUS SIGNALS

CURRENT-LIMIT OUTPUT

This is an output signal which is HI (+5V) when the amplifier is not current limiting. As the current limiting starts to take effect the /CLIMIT output will go LO (0V).

This is very useful for a closed loop control system that expects the amplifier to be operating in a linear manner. Since, the /CLIMIT line transitions LO on the first detection of current limiting, the controller can be alerted to non-linear behavior immediately.



LED INDICATOR FUNCTIONS

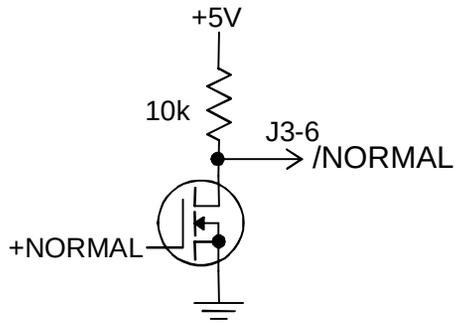
Color and state of LED indicates amplifier operating conditions

LED COLOR	CONDITION	ACTION to ENABLE
Flashing Green	Ready (AMP OK)	Activate /ENABLE
Green	Normal	None
Red	Fault	Power, /MOTEMP (J2-9)
Flashing Red	Latching Fault	/Reset, Power OFF/ON

Ready = Amp OK AND NOT enabled
Normal = Amp OK AND enabled
Amp OK = Internal buss voltage is within limits AND NOT Fault

Fault = Over voltage, under voltage, or motor overtemp.
Latching Fault = Output short circuit or heatplate overtemperature. Amplifier 'latches' off and stays off until reset.

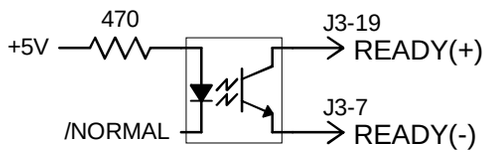
/NORMAL OUTPUT SIGNAL



N-channel mosfet with 10k-ohm resistor connected to +5V.
Maximum voltage: 50VDC. Maximum current 250 mA.
On-resistance = 5 ohms.
Output is LO (mosfet ON) whenever amplifier is enabled and NORMAL (LED Green)
Output is HI (mosfet OFF) whenever amplifier is NOT enabled, or FAULT occurs.

OPTO-ISOLATED NORMAL OUTPUT SIGNAL

This AMP OK signal indicates that the amplifier ready to run. It is completely optically isolated from the amplifier. The input of the optocoupler is driven by the amplifier logic circuits, and the output is a floating NPN transistor with both terminals brought to signal connector J3 as shown below.



Maximum voltage = 32VDC. ON current = 4mA. minimum
Output transistor ON voltage: 0.4 at 4mA

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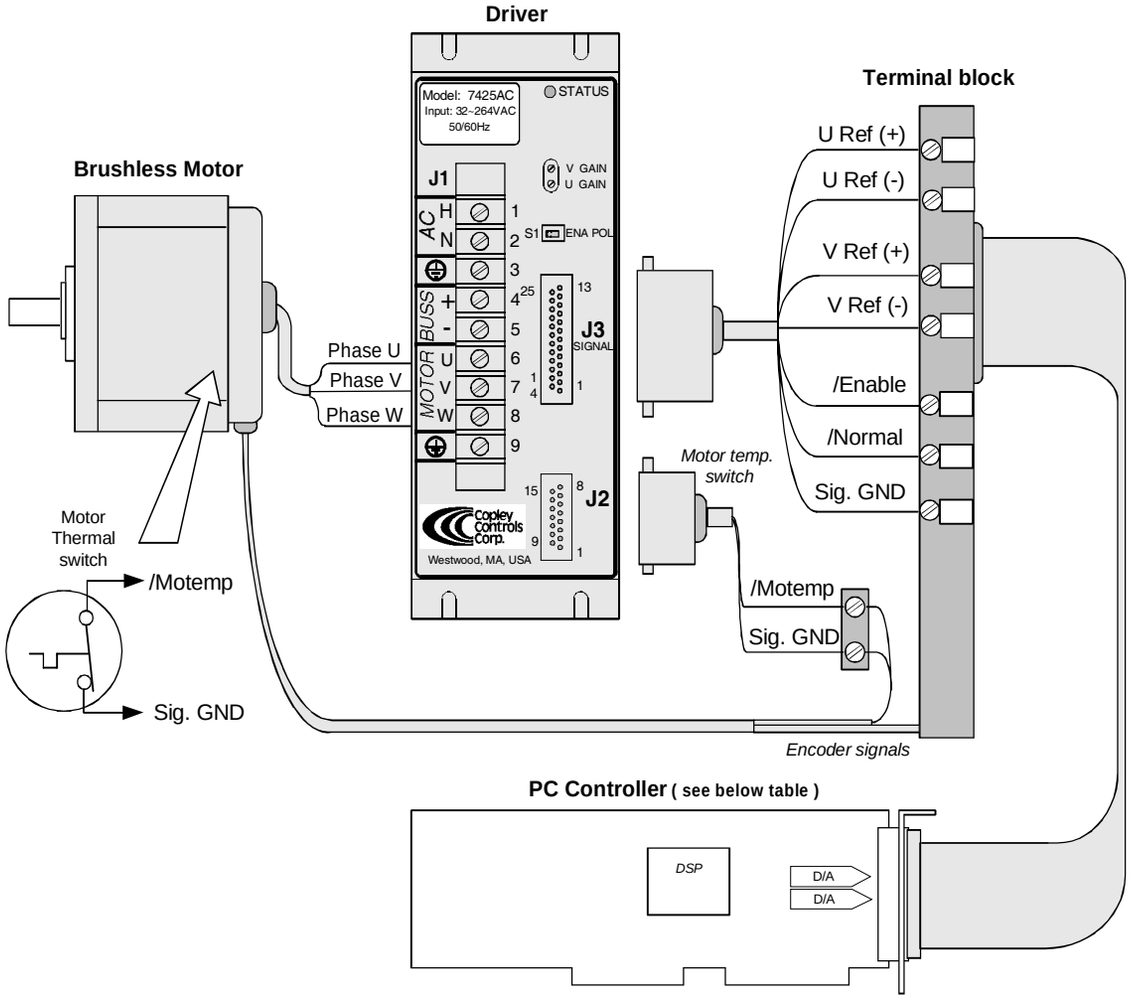
INTERFACE DIAGRAM



CONTROLLERS

Here is a list of several controllers are available that perform sinusoidal commutation. These controllers use a DSP in conjunction with double DAC analog outputs to perform multi-axis motion control. They are configured for several buss platforms such as ISA, PC104, VME, and STD. For more information, about controllers, please contact the below manufacturers.

Manufacturer	Model	Description	Web site
ACS-Tech80	5651A	ISA bus card for to 4 Axis	www.acs-tech80.com
ACS-Tech80	SPiiPlus Series	Stand-alone controller	www.acs-tech80.com
PMD	DK 1231A-P	Developers Kit for 2 Axis	www.pmdcorp.com
Motion Engineering Inc.	PCX DSP	ISA bus card for to 4 Axis	www.motioneng.com
Delta Tau	PMAC1	ISA bus card for to 4 Axis	www.deltatau.com
Galil	DMC-1700	ISA bus card for to 4 Axis	www.galilmc.com

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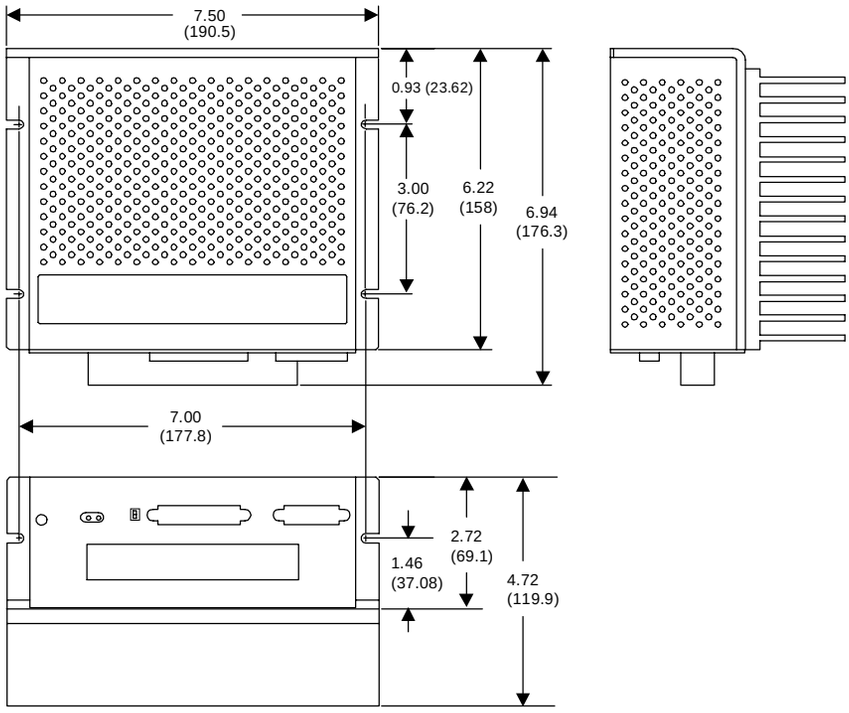
OUTLINE DIMENSIONS



Dimensions in inches (mm)

Weight 3.71 lbs. (1.69 kg) without optional heatsink. Add 3.2 lbs. (1.47 kg) for heatsink.

CONNECTORS	J1: Power & motor	9-position terminal strip
	J2: Halls / Options	15-position female Sub-D type. #4-40 standoffs for cable shell lock screws
	J3: Signal	25-position female Sub-D type. #4-40 standoffs for cable shell lock screws
		Connector shells are connected to amplifier chassis for grounding/shielding

ORDERING GUIDE

Model 7225AC	20A peak, 10A continuous, from 32~132VAC, 50/60Hz AC mains
Model 7425AC	20A peak, 10A continuous, from 32~264VAC, 50/60Hz AC mains

Notes:
1. Add "H" to model number to specify heatsink option.

OTHER ANALOG BRUSHLESS MOTOR AMPLIFIERS

Low-drift, ±10V U-V Command Inputs, 24~180 Vdc power sources

7225X1 10 Acont, 25 Apeak,

7225X1-50 15 Acont, 50 Apeak

7225X2 2-axis, 10 Acont, 25 Apeak

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